

The Importance of Pairwork in Interdisciplinary and Educational Initiatives

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Abstract – An early and prominent employee of Google, Georges Harik, recently made the assertion that pairs working together in startups are 20 times more productive than individuals working alone. The author has also personally experienced the boost of what is here termed *pairwork* in a university setting during the startup phase of several educational and interdisciplinary initiatives. The paper briefly explores pairwork in the history of technology and constructs both qualitative and little quantitative models of pairwork. The quantitative model under reasonable assumptions easily recovers Harik’s 20x boost. The paper also briefly examines the author’s recent experiences with pairwork in four interdisciplinary and educational initiatives.

Index Terms – pairwork, organizational change, interdisciplinary initiative, educational reform

INTRODUCTION

A former student, Georges Harik, a very early employee at Google, gave a talk at the University of Illinois not long ago and asserted that “pairs of individuals are 20 times more productive in startups than individuals working alone.” This assertion struck me forcefully and personally, because I realized that in four different startup activities for educational transformation and interdisciplinary research that I had been involved in pairwise activities in important ways. Moreover, it seemed to me that the literature of teamwork since the quality revolution placed a good deal of emphasis on teamwork, but didn’t say much about the smallest teams or what we will here call *pairwork*. Getting smacked in the head with Harik’s intellectual two-by-four, my own successful experiences with pairwork, and the realization that pairwork might be

systematically undervalued led to further reflection on the organization of startups and organizational initiatives, and this paper presents the first fruits of that inquiry.

In particular, the paper explores the importance of pairs historically, anecdotally, and theoretically. In particular, the paper starts by recalling a number of famous pairs in technological history, as well as some less-than-famous pairs that provide historical evidence for the importance of pairwork.

The paper continues by building both qualitative and little quantitative models of pairwork in an effort to understand key mechanisms and also understand whether Harik’s 20x factor of improvement is at all reasonable. The paper concludes by briefly reviewing the author’s experience in four different interdisciplinary and educational initiatives, suggesting that pairwork may be a useful principle for encouraging creative change in engineering education and interdisciplinary initiatives.

GREAT PAIRS IN TECH HISTORY

We need only scratch the surface of the history of technology to find a number of great pairs behind many of the great inventions and technological organizations of the past century or so.

For example, the 20th century was welcomed by the activities of arguably the most famous pair in technological history—the Wright brothers—whose activities culminated on December 17, 1903 with the first manned, powered, heavier-than-air aircraft flight at Kitty Hawk, NC [1].

John C. Lincoln started the Lincoln Electric Company and was later joined by his brother, James F. Lincoln forming a classic pair with John C. providing technical prowess and James F. providing managerial creativity [2].

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David Packard and Bill Hewlett started the company we now know as HP in a garage in Palo Alto, CA. Although both were trained engineers, like the Lincoln brothers, Hewlett and Packard formed a classic technologist-manager pairing [3].

There is no lack of more recent successful technological pairwork. For example, Apple Computer was founded by the duo of Steve Jobs and Steve Wozniak, and more recently the now-famous pair of Larry Page and Sergey Brin founded Google in yet another famous Silicon Valley garage.

The existence of famous pairs is not itself evidence that pairwork has a particular advantage over the “lone” inventor, but it is interesting to note that some of the cases we think of as solo invention are hidden or invisible cases pairwork.

INVISIBLE PAIRS

Although founding pairs are quite prominent in technological lore, there are many unsung cases of pairwork—what we might call *invisible pairwork*—that take place beneath the surface, hiding behind the public image of a great inventor.

One prominent case, arguably the archetypal case, is that of the great “lone” inventor, Thomas E. Edison. Although Edison is often thought of as a heroic solitary inventor, his work was mightily amplified by close, pairwise working relationships with such talents as William J. Hammer, Charles Batchelor, and Samuel Insull [4]. We won’t dig into those relationships here, except to observe that the prevalence of pairwork may often be masked by the fame of one of the pair members.

Whether visible or invisible, working in pairs seems to have played a role in great achievement in the history of technology and engineering. Next, we turn to trying to understand how pairwork may play an important role, particularly new or creative activities.

COMPLEMENTARY SKILLS: PART OF THE STORY

Although the paper started by contrasting pairwork with teamwork in larger settings, there is

an extensive literature on teamwork, and we should expect it to have something to say about pairs vis-à-vis individuals working alone. A particular prominent feature of discussions of teams in general is the emphasis on the assembly of members with *complementary skills* [5], and we’ve already hinted at its importance by highlighting that a number of the pairs mentioned above had one individual of strong technical skill and one of strong managerial or leadership skill.

Although it is difficult to generalize, there are a number of common pairings that arise: insider & outsider, tech & business, manager & salesman, visionary & detail person, extravert & introvert, and discipline₁ & discipline₂. This list is not exhaustive, and next we examine a qualitative model of why pairwork may be important.

A QUALITATIVE MODEL OF PAIRWORK

Complementary skills are critical to effective pairwork, but what other factors might help account for Harik’s 20x power boost of a pair over a singleton? Simple reflection on vocational, psychological, and material factors results in the following list of six elements:

1. Complementary strengths, skills & traits
2. Personal compatibility
3. Dialectic creativity
4. Coordination costs
5. Motivational leveling
6. Sociocultural negotiation in miniature

The section examines each of these in turn.

Complementary strengths, skills, and traits

The first of these has already been considered at some length, but here we explicitly differentiate between signature strengths, vocational skills, and personality traits [6], acknowledging that pairings can be based on a variety of factors.

Personal compatibility

Aristotle was an early commentator on different kinds of alignment in friendship [7], and there is a burgeoning literature on personal compatibility,

friendship, and even websites that match potential spouses based on personality and preference instruments, but the essential point here is a simpler one. Good pairwork does not require the two parties to be best friends, but it does require that the individuals (1) work together for long periods and (2) respect each other's contributions and strengths.

Dialectic creativity

The organizational literature on innovation has recognized dialectic innovation or creativity as an important mode for some time [8]. Of course, Socrates was infamous for walking around Athens and asking questions and making arguments to come to a clearer understanding of some philosophical point [7], and the rapid expansion of human knowledge following the cultivation of that particular habit of mind was remarkable.

In the current setting, the move from an individual trying to be creative on his or her own to pairwork is important, because two is the smallest number of individuals that can get together and have an honest disagreement with the hopes of a creative solution. Indeed, a single individual can argue with him or herself, but the opportunities for self-delusion are too ready at hand.

Coordination Costs

The move from one person to two has the benefit of increasing the possibility for dialectic creativity, but there are attendant costs, and the primary costs are those of coordination. Although you do manage your time, in a sense you don't really have to "coordinate" yourself, but as soon as you move to working with at least one other person you need to communicate, negotiate and decide, divide work, and synchronize tasks.

In this way, a pair is that grouping of people in which you can have real interpersonal dialectic and creativity for which coordination costs are likely to be reasonable.

Motivational leveling

One of the difficulties of working alone, especially in challenging new initiatives, is that

the difficulty of the work can cause creeping doubts about your ability to succeed. Unlike routine work, where the task, detailed work procedures, actors, and desired outcomes are all known, initiatives and startups of all kinds start empty, demanding continual creative efforts without let up, responding to variance of a just-invented and untested work procedure, looping through the emotional highs and lows of an unfamiliar work force, hurdling hopefully on an oscillating path toward an uncertain outcome. Although those who join startups or initiatives often do so seeking to explore uncharted territory, the usual rough ride can challenge even those who have been there before.

As such, one of the benefits of pairwork is that the two members of the pair can work together to keep the motivational level high and relatively smooth. With a pair, the chances that at least one of the two members will be up and handling a crisis is higher than a singleton acting alone, and if the pairs are sufficiently compatible and the pair has learned to work together, the pair member who is up can elevate the pair member who is down.

Sociocultural negotiation in miniature

The foregoing factors are important and can help build a case for the use of pairwork in appropriate settings, but an interdisciplinary project with two or more disciplines at the table, can be particularly challenging because of the cultural differences that often exist between them. We don't often think of disciplinary interactions in cultural terms, but anthropology studies symbols, rituals, norms, and roles, and such things exist in modern organizational settings, whether we acknowledge them or not.

As such, pairwork can work quite well to make sure that some larger team or activity that requires the successful interaction of individuals from two cultures has been worked out in a way that respects the traditions of the different constituents. We'll examine a particular example of pairwork that brought engineers and philosophers together in a later section, but just the mention of "philosophers" and "engineers" in the same

sentence is sufficiently jarring that one realizes that leadership of an such an initiative by either a philosopher or an engineer is unlikely to make much headway with a group comprised of both.

Taken together, the six factors above help us understand pairwork somewhat better, and the qualitative modeling lead to straightforward quantitative models, a topic taken up next.

LITTLE QUANTITATIVE MODELS OF PAIRWORK

We cross what I have elsewhere [9] called the *qual-quant divide* by starting with three facets of the qualitative model above, complementary skills, leveling, and dialectic, deriving little models [10] (LMs) of each facet using reasonable assumptions, thereafter integrating the three models together. In so doing, we easily recover Harik's factor of 20 with reasonable assumptions.

LM1: Complementary skills

Consider a singleton performer with two skills (skills 1 and 2) and assume that the singleton performs skill 1 with a probability of success p , and skill 2 with probability $q = 1 - p$. Assuming that the overall task requires success at both skills and that the individual events are independent. Thus, the singleton success probability may be calculated by elementary means as pq .

Consider a pair with two individuals one of whom has the singleton performer's skill set p (p, q) and the other of whom has a complementary skill set to the first (q, p). The probability of failure in either skill is the complementary probability of failure by both actors. Thus, elementary calculation yields a probability of pairwise success as $(1 - pq)^2$.

Finally, letting the $p_1 = pq$ and dividing the pairwise success by the singleton success and calling that quotient the *boost* B , yields a boost value $B = (1 - p_1)^2/p_1 = 1/p_1 + p_1 - 2$. For specialized and complementary pair members, the boost approaches $1/p_1$.

LM2: Motivational leveling

In motivational leveling, assume a singleton has a probability of being up of p_2 , and a pair is up if

both of them are not down or a probability of $1 - q_2^2$. Thus, the boost of motivational level B_2 is the pair-to-singleton ratio or simply $B_2 = 1 + q_2$, which can be as large as 2.

LM3: Creative dialectic

Assume a singleton has probability p_3 of successfully being creative on a given challenge. Without effective interpersonal dialect, we assume the individual makes no further progress.

Each individual in a pair has probability p_3 , of individual success. Taking the pairwise one-shot success as the union yields a probability of $2p_3 - p_3^2$. Taking the ratio, the one-shot boost is simply $2 - p_3$, which can be as high as 2; however the pair is not done, and continued dialectic is assumed to solve the unsolved portion of the problem with repeated one-shot success on each succeeding unsolved part of the problem. We won't do that iterative calculation here, but we observe that this iteration quickly approaches pairwise success of 1. Thus, we take the long-term boost with iterated pairwise dialectic to be $B_3 = 1/p_3$.

Product model

Assuming that the overall effects are independent and required for effective action, we calculate the overall boost as the product of the individual effects, $B \approx 2/(p_1 p_3)$, using bounding values, as precision is not required for our purpose.

Assuming that parties to the pair are specialized suggests the probability p_1 is small. Assuming that the dialectic challenge is difficult suggests that p_3 is small. Taking example values of both parameters equal to 0.2 yields a boost $B = 50$, easily exceeding Harik's asserted value.

PERSONAL REFLECTIONS ON PAIRWORK

This paper began as a talk given in June 2008 at the National University of Singapore not long after Georges Harik's talk earlier that year. The basis for my personal reflections on pairwork was a sequence of four pairwork activities that had started two years earlier. In 2006, I blogged about the lack of philosophy of engineering, and this led to pairwork with Michael Loui creating Engineering and Technology Studies at Illinois

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(ETSI), a trusted network of engineering faculty and faculty from the humanities, arts, and social sciences examining engineering as a human activity. It also led to pairwork with TUDelft philosopher Ibo van de Poel in the creation of the first Workshop on Philosophy and Engineering in 2007 (WPE-2007). The ETSI work also led to pairwork in the formation of the Illinois Foundry for Innovation in Engineering Education (iFoundry) with Andreas Cangellaris as well as pairwork Sherra Kerns in the formation of the Olin-Illinois Partnership.

Although, we won't consider the inner workings of each of these activities here, the effects modeled in this paper were clearly evident in the four activities. All four activities benefited from the complementary skills of pairwise actors working together with reasonable compatibility. Time after time the work product of the pair was more creative than either that of any single individual, but solutions were concocted quickly without the overhead of a larger team. Repeatedly one of the pair prodded the other or offered words of encouragement when things weren't going well. In those cases where there were different cultures to bridge, each pair member successfully brought their insider cultural understanding to bear on important initiative design questions.

The results of this paper are suggestive, and clearly more work is needed, but engineering education appears to be at a crossroads where change, initiative, and interdisciplinary work are essential. More research needs to be done before this work can be considered scientifically solid, but engineers know a good clinical opportunity when they see one. The paper suggests that pairwork may be a useful organizational innovation at exactly that moment where interdisciplinary and educational initiatives are at a premium and merely sticking with the status quo is increasingly unattractive.

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