

Agile Values, Innovation and the Shortage of Women Software Developers

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Abstract

The percentage of women software developers in the U.S. has declined from 42% in 1987 to less than 25% today. This is in a software/internet marketplace where women are online in equal numbers to men; directly or indirectly influence 61% of consumer electronics purchases; generate 58% of online dollars; and represent 42% of active gamers.

Women avoid careers in software due to hostile environments, unsustainable pace, diminished sense of purpose, disadvantages in pay, and lack of advancement, peers or mentors.

Agile Software Development is founded upon values that challenge such dysfunction in order to build self-organizing, collaborative and highly productive teams. In a high functioning Agile practice, developers engage each other, product owners and sponsors in a shared concern for quality, predictability and meeting the needs of end users.

Can Agile values and practice drive changes in the workplace to better attract and retain women software developers?

1. Introduction

Women are opting out of software jobs despite high demand for skilled developers. Women are also leaving mid-career in disproportionate numbers.

This is a lost opportunity. Research conducted over twenty years on serially innovative companies shows that product teams representing the diversity of their customers have an advantage in developing products that appeal to those customers.

Agile Software Development is greatly influenced by this research. Agile consists of many practices united by a set of principles and an ambition to change the software industry's approach to building products.

While the Agile community dwells on methods and tools, what fundamentally unites practitioners are a core set of principles reflected in the Agile Manifesto and distilled into the following values[1]:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation

- Customer collaboration over contract negotiation
- Responding to change over following a plan

Agile practices are tools. Agile principles give us practitioners the urgency, courage and insight to wield those tools toward a desired outcome. We will therefore create a workplace more tolerant and inviting to women if we recognize gender disparity as an impediment to our core Agile mission.

In this paper, we will demonstrate that gender disparity exists and that it is an impediment to product success. We will identify factors in the workplace that discourage parity. Finally, we will explain why Agile values of collaboration, craft, quality and delivery are a framework for addressing these factors.

2. Women are underrepresented in CS

Women are less likely to aspire to a career in computing, less likely to pursue a degree in computer science (CS), and less likely to work as software developers. Those women who do make a career in high tech are far less likely to attain a leadership role and much more likely to leave mid-career.

According to the US Bureau of Labor Statistics (BLS), women represent 46% of the workforce but only 30% of Information Technology (IT) workers and less than 25% of software developers. Over the last twenty years, the percentage of women developers has steadily declined. The disparity is worse in leadership. Women account for only 10% of executives in fortune 500 computer companies[2].

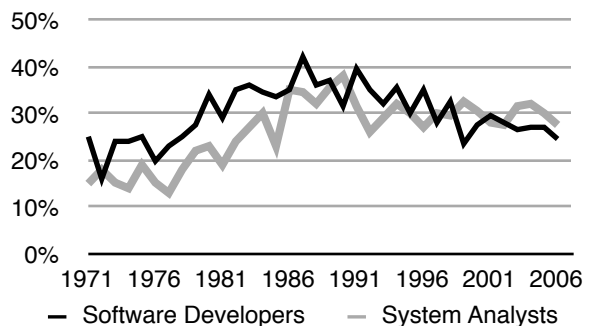


Figure 1. Women in the workforce[3]

2.1. Women are leaving mid-career

Women are leaving IT in larger numbers than men. 56% of women leave mid-career across all technology occupations. 41% leave their careers in “high technology” compared to only 17% of men. Half of women leaving Science, Technology, Engineering and Math (STEM) careers leave the STEM sector completely[4].

2.2. Women are not studying CS

Women are opting out of CS education in larger proportions than men. While men earning CS bachelor’s degrees between 1986 to 1995 dropped 35%, the number of women in the same period dropped by 55%[5].

Currently, the percentage of women studying CS in undergraduate and graduate schools is still falling[6]. This despite 1.3 times as many women attending and 1.35 times as many women graduating from four year colleges (2003)[7]. By 2004 women accounted for less than 25% of CS bachelor degrees. This is not typical of STEM more generally where 49.2% of bachelor degrees go to women[8].

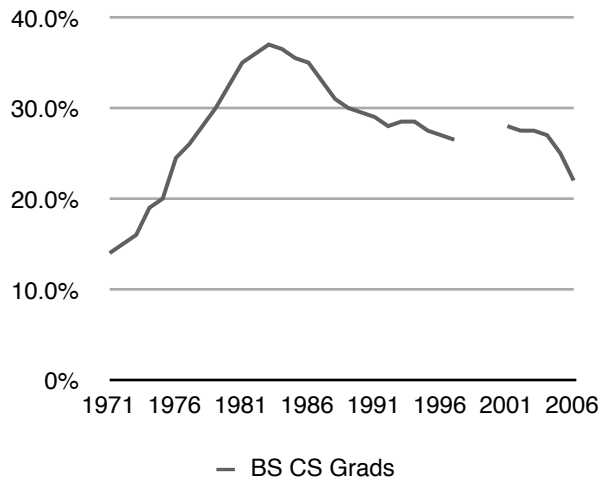


Figure 2. Women obtaining CS degrees

2.3. Women are disinterested in programming

Young women are not interested in hard IT careers like computer programming. The *Maryland Adolescent Development in Context Study*, a longitudinal study of 1,482 adolescents conducted between 1991 and 2000 shows women are less interested in CS careers than men overall. White women are more disenchanted compared to African Americans of both genders and white men. 62.2% of white women in the study indicated no interest in any IT-related career and were

the least likely to aspire to hard IT or pursue a degree in CS[9].

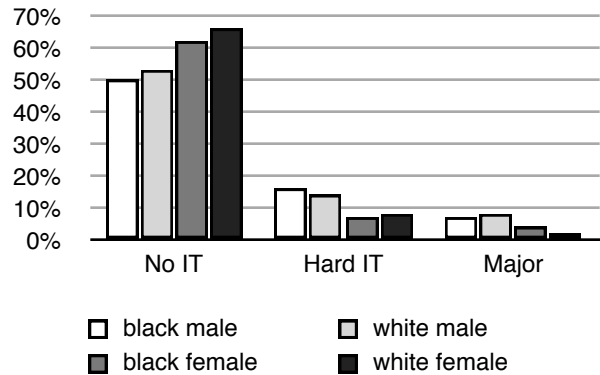


Figure 3. IT career aspirations by group

3. At what cost to the software industry?

The software world struggles with Diversity as it is. It's a problem for our profession, in that we lose access to talent, and it's a problem for many women who don't get the chance to develop a satisfying career in programming. The open-source world in general has even bigger issue, and the rails community perhaps more so – Martin Fowler[10]

3.1. The need to hire

In 2002, the U.S. software industry represented \$200B in sales and by 2006 employed 2.2M software professionals[11].

The U.S. Department of Labor (DOL) considers IT to be “among the economy's largest and fastest sources of employment growth” having adding 616K jobs between 1994 and 2004 and projected to add, despite outsourcing, productivity gains and the recession, 453K jobs through 2014[12].

Whether there is a shortage of skilled domestic IT workers is a matter of debate entangled in arguments over quotas and off-shoring. J. Luftman of Stevens Institute of Technology, argues there is citing as evidence[13]:

- McKinsey & Co. predicts demand for experienced IT professionals in the U.S. aged 35-45 will increase by 25% while the available pool will decrease by 15%.
- 51% of senior executives participating in a 2007 SIM survey cited "attracting, developing, and retaining IT professionals" as their top concern.

3.2. Aligning the domestic workforce

Regardless of whether we can address the demand for IT with foreign labor, the U.S. has an excess of

domestic workers in non-growth sectors. 71% of U.S. workers are in jobs with low demand or an oversupply of eligible candidates[14].

“America needs a world-class STEM workforce”– John Holdren, President Obama’s science advisor and director of the White House Office of Science and Technology Policy

Government and industry leaders believe it is in our U.S. national interest to increase the pool of employable domestic IT workers. According to the DOL, the IT sector will grow to accommodate them.

3.3. The cost of attrition

In 2008, HR Management magazine calculated that replacing a worker costs on average 100-125% of an employee’s annual salary[15]. A mid-career software developer is highly compensated and, given the complexity of legacy codebases, possesses valuable institutional knowledge. Replacing her is expensive.

How expensive? According to the BLS, there were 588K[16] women employed as computer engineers in the United States (2006) with a median wage of \$85K (2008)[17]. 56% of them leave. Retaining one-quarter of those women would represent a ten year value of 82K experienced software developers retained at a savings of \$8B to their employers.

3.4. Lost opportunity in the software industry

3.4.1. Our customer is a woman. Women directly or indirectly influence 61% of U.S. consumer electronics purchases[18]. Men still spend more annually on average, \$969 compared to \$631 for women, but they often do so in consultation with their significant others.

Women are 42% of active game players and 48% of frequent game purchasers. Women 18 and over are 37% of game players whereas boys 17 and under are only 13%[19].

Half (50.4%) of the internet population are women 18 and over. They spend an average of 38 hours per month online in close parity with men. They spend 5% more time than men engaged in online social activities and their time spent on social networks is growing more rapidly. Women spend 20% more time on online shopping and account for 58% of internet buyers, 61% of internet transactions and 58% of internet dollars. They account for the majority of dollars spent online for apparel, media, home and living, toys, hobbies, video games and consoles. They account for 49% of the dollars spent on computers and electronics[20].

In other sectors, companies as diverse as Home Depot, Best Buy, Kodak and Nike created or grew significant markets by shaping products and services around classes of women consumers[21].

3.4.2. Women are underserved. Software products are generally designed with no consideration for women as

distinct user groups. In “Gender differences in Web Usability”, F. Spillars states, *“Gender as an audience sensitive criteria (differentiation) is barely present in North American technology product design (where it is much easier to do) let alone Web experiences[22].”*

But there a statistical differences in how women perceive and use software. L. Xue, et.al. found differences in the ways men and women perceive and describe products. *“The results of this research have revealed female-oriented themes that should motivate product semiologists, sociologists, and design researchers to enlarge their views of pleasurable product design attributes and language for the genders[23].”*

This lack of consideration underserves women. Boston Consulting Group (BCG) highlights three ways companies fail. *Poor product design*: failing to tailor products to women’s unique needs and challenges. *Clumsy sales and marketing*: based on outdated images and stereotypes. *Inability to provide meaningful hooks or differentiation*: considering women indistinguishable from the general customer population or thinking of them as one monolithic segment[24].

In underserving women the industry perpetuates the sense that software is male. Moss et.al. state: *“...men had a statistically significant tendency to prefer home pages produced by men, and women those produced by women. This latter tendency was higher than the former[25].”*

This disadvantages women as both end users and content creators: *“We thoroughly analysed a number of randomly selected web designer software... most of them are typical masculine templates, which makes it difficult [for] women to design a feminine looking website. It can be one of the reasons of the masculine website hegemony on the web[26].”* Horvath et.al.

3.4.3. Potential for harm. Failure to adequately understand and address the needs of women may harm them in ways we cannot anticipate. Software systems are a fundamentally complex product that can produce unintended consequences.

Women find the internet a more hostile space than men do. More women experience information overload on the internet (24% to 19%), are less confident in use of search engines (40% to 54%), and are more concerned about theft, fraud and privacy[27].

“In the discreet world of computing, there is no meaningful metric in which small change and small effects go hand in hand.” - (Dijkstra 1989. p. 1400) ... the normally predictable linkage between acts and their effects is severely skewed by the infusion of computing technology[28].”

In medicine, Doctors were slow to recognize how common heart disease is in women despite the mortality rate because, “So much of our understanding of the underpinnings of heart disease and heart attack, and the basis for our standard methods of diagnosis and

treatment are the result of research conducted on men[29].” In another recent example, research found women require lower dosages of particular anti-psychotic drugs. Not considering this subjected women to wide-scale overdosing and more frequent and serious side effects[30].

4. Why women are avoiding and, worse, leaving software development

The *Athena Study* by the Center for Work-Life Policy identifies “antigens” in STEM cultures. *Hostile macho cultures*: 63% of women experience sexual harassment. *Isolation*: women are alone on teams with no mentors or sponsors. *Mysterious career paths*: 40% of women feel stalled or stuck. *Systems of risk and reward*: the “diving catch” culture disadvantages women who would rather prevent emergencies than save the day. *Extreme work pressures*: unsustainable hours and stress[31].

The *Why So Few* study by the American Association of University Women (AAUW)[32] adds that girls from a young age are more likely to *doubt* they can succeed in STEM careers. They believe certain STEM careers like software engineering do not have *meaning* or *social purpose*. They have conflicting *family responsibilities*. Finally, they face *gender biases* such as those expressed by former Harvard University President, Larry Summers. This despite evidence that what cognitive differences exist statistically between genders can be negated with training or do not correlate to success in STEM.

The Catalyst Study sponsored by IBM adds women find themselves excluded from special job assignments, don’t understand unwritten norms shared by men, and don’t fit the corporate image of a manager[33].

J. Hunt challenges the causal significance of social factors highlighted in the studies above. She argues that disproportionate levels of attrition in STEM must be attributable to causes that are disproportionately reported by women in STEM careers. By analyzing a decade of national surveys of college graduates she concludes the only differentiated causes are lack of pay and advancement which she closely correlates to workplaces dominated by men[34].

However, as stated earlier, representation in CS declined even as it improved in other areas of STEM with lower percentages of women in the field. In the last ten years, the percentage of women in Engineering has risen from 9.1% to 10.6% and women in Physics and Astronomy from 12.9% to 13.9%[35]. CS remains an outlier.

5. Agile Software Development

Agile Software Development is a response to a perception of high failure rates in the software industry. It is also a reaction against high formality, plan-driven approaches to software construction on the one hand, and low formality, chaotic approaches on the other. Agile adherents associate both extremes with waste, low quality and burnout among software project participants.

Agile actually encompasses many separate software management and execution methodologies formed independently over twenty-five years. Its practices incorporate influences from pre-existing iterative and evolutionary development methodologies, empirical process control, knowledge creation, games theory, lean manufacturing, and learning gleaned from highly productive teams.

Ten years ago, prominent advocates of these practices came together to declare a shared commitment to a set of principles they call, The Agile Manifesto. Since then, they and an increasing number of others have self-identified as Agile. Groups such as the Agile Alliance provide venues in which to discuss, debate teach and evangelize these principles and practices.

5.1. Agile values

“At the core, I believe Agile Methodologists are really about ‘mushy’ stuff about delivering good products to customers by operating in an environment that does more than talk about ‘people as our most important asset’ but actually ‘acts’ as if people were the most important, and lose the word ‘asset’. So in the final analysis, the meteoric rise of interest in and sometimes tremendous criticism of Agile Methodologies is about the mushy stuff of values and culture.” – Jim Highsmith[36]

Agile principles form the basis for a normative standard of conduct informing how practitioners should behave towards work, peers, employers, customers and end users. It urges us to inspect our actions, confront impediments, and drive towards beneficial change even as we deliver valuable, high quality software.

As Bob Martin describes it, “Most software development teams execute, but they don’t take care. We value execution, but we value craftsmanship more.” To emphasize his point he announced a desire to add an additional high-level value to the manifesto, “We value craftsmanship over crap.” Or more precisely, “We value craftsmanship over execution[37].”

Alistair Cockburn believes a commitment to quality and craft is embodied in the manifesto as written suggesting that the problem is rather to remind

practitioners to, "...value agile principles over the agile practices[38]."

In championing different themes, contributors to the manifesto emphasize primacy of values over practices in different ways. Bob Martin demands craftsmanship. Jim Highsmith extolls collaboration. Martin Fowler advocates diversity. Jeff Sutherland calls for hyper-productive, accountable teams. Ken Schwaber insists on individual integrity. Mary Poppendieck describes waste. Kent Beck argues for responsible development.

What these themes have in common is a challenge to practitioners to commit to more than success narrowly defined on a project or a particular job but to build a career addressing the real needs of people. To have pride our accomplishments and be proud of who we are as we attain them. Not simply to execute but to take care.

So, in asking how agile practice might help reverse the flight of women from software development, we'll follow Alistair Cockburn's advice. Rather than ask, "What Agile practices address this problem?" We will ask, "What Agile principles demand we confront this problem?"

6. Agile values within the team context

6.1. Team diversity, requisite variety and innovation.

The writings of Nonaka and Takeuchi are the roots of the most widely adopted Agile process framework, Scrum[39]. Nonaka and Takeuchi emphasize that a team made of members with different backgrounds, perspectives and motivations is critical for organizational knowledge creation to take place[40]. Knowledge creation being the basis of repeatable innovation in companies.

"...[A]n organization's internal diversity must match the variety and complexity of the environment in order to deal with the challenges posed[41]."

Successful software product teams test a product continually, developing prototypes quickly[42] and rely on shared tacit knowledge that customers cannot exactly or explicitly express[43]. In the classic Matsushita case study, it was an engineer's visceral experience of baking that led to breakthroughs in Bread Maker design. Coincidentally, she was a woman[44].

This argues for diverse product teams with individual contributors that share tacit knowledge with customers who can express that understanding in the product through nonverbal means.

Specific to this paper, women have different perceptions of software than men. Women are significant customers and influencers in the buying decision. It is competitive advantage to have women as individual contributors on the development team to collaborate and share their tacit knowledge.

6.2. Self-directed, performing teams - an antidote to the Geek culture and un-written norms.

"Alpha male techies have minimal social skills and can be awkward around women, but this awkwardness coexists with enormous arrogance[45]."

"The nub is that whatever the presenter may think, people were offended... It doesn't matter whether or not you think the slides were pornographic. The question is does the presenter, and the wider community, care that women feel disturbed, uncomfortable, marginalized and a little scared[46]."

At the heart of Agile principles is primacy of team, one of three roles in Scrum: *"the skills that Team members share – that is, the skill of addressing a requirement and turning it into a usable product – tend to be more important than the ones that they do not. People who refuse to code because they are architects or designers are not good fits for Teams. Everyone chips in, even if that requires learning new skills or remembering old ones. There are no titles on Teams, and there are no exceptions to this rule. Teams do not contain sub-Teams dedicated to particular domains like testing or business analysis, either[47]."*

In a performing team each member relates to the other as equals. A principled Agile team will not tolerate a hostile environment towards a teammate or the business people upon which it depends for work. Through the sometimes conflict ridden process of team building, each member will come to tacitly understand and participate willingly in the un-written norms of behavior that define the team's identity. The team will inspect its own behavior and continuously improve the social skills required to communicate. This is a requirement for trust and the kind of collaboration that leads to cohesion and self-direction.

As Jeff Sutherland says, one of the secrets to a hyper productive team is: *"Team members that share a sense of purpose, vision, and passion for their work. Teams that recognize that we are not simply individuals working in close proximity, but a team where we must all be engaged with one another's work. I tell teams looking to achieve amazing results that each member of the team must care as much about their neighbor's work as they do their own[48]."*

Given the team and its management understands and champions this vision, they will find practices across the Agile methodologies to help them achieve the desired outcome. Chief among them: keeping team size between 5-9 people, communal workspace, retrospection, group planning and estimation, and a shared iteration commitment.

In listing techniques, we make no claim that applying these techniques will predictably and reliably build performing teams. Team performance requires shared vision, tough, honest conversations, sometimes

tough management decisions and a functional mix of people. It requires courage and a willingness to change from all team members. So, the ultimate answer for the alpha male who breaks the cohesion of the team, is he either modifies his behavior or he is off the team.

6.3. Collective ownership - an antidote to heroics, exclusion from special job assignments, and marginalization to support roles.

“Many SET cultures place a high value on risky behaviors: They celebrate heroic diving catches made at the eleventh hour to rescue a failing project. However, men and women are rewarded differently for taking risks, and women—who lack strong “buddies” and a cheerleading group—cannot bounce back if they dive and miss. In fact, even when they dive and catch, their lack of support means their effort often goes unnoticed. Finally, women are often pushed into the less flashy and less valued executor-type roles[49].”

Heroics are an anti-pattern to the principle of quality both for what happens to code produced in an emergency and for what is implied by a codebase that generates urgent, unplanned failures in the first place. Coding is an exercise in learning, creative problem solving and a careful balance of what delivers the best solution given the constraints of the moment and what will produce a versatile, maintainable solution for the long-term. The best adjective for quality code is elegant, the best solution tailored to the immediate needs executed in the simplest most expressive language. Elegant code is best produced by a developer motivated and focused but also alert, rational and rested.

When developers work past endurance or under duress, they make mistakes -- they make expedient, flawed choices that vary from the established patterns of the larger codebase. They produce blocks of code which only one person understands or makes no coherent sense to anyone after the fact. They introduce bugs. A “hero” doesn’t have time to refactor or comment their code, care whether their solution performs, addresses unusual conditions, or how much time or effort it takes two months or two years later to change.

All of this defeats a principle of self-directed teams called, collective ownership. *“Collective Ownership encourages everyone to contribute new ideas to all segments of the project. Any developer can change any line of code to add functionality, fix bugs, improve designs or refactor. No one person becomes a bottle neck for changes[50].”*

Collective ownership is key to quality and delivering value. With it, team members are empowered to improve code as they go, allowing for pride in craft and a maintainable, adaptable code base.

Without collective ownership, codebases slowly accrete work-arounds until they become entirely opaque and unmanageable. Changes that took days can take weeks and businesses become unable to deliver valuable enhancements to users.

“Why don’t we just build the system right in the first place? Women are much better at preventive medicine. A Superman mentality is not necessarily productive; it’s just an easy fit for the men in the sector.” Because it is generally men who are making the promotion decisions, they recognize this behavior and reward it[51].”

Collective ownership discourages the use of specialists which represent bottlenecks and opaque stores of tacit knowledge. The Scrum guide includes as the basic definition of team, *“There are no titles on Teams, and there are no exceptions to this rule. Teams do not contain sub-Teams dedicated to particular domains like testing or business analysis, either[52].”*

So, a team that embraces Agile principles, should dismantle the culture of the “diving catch”. There should be no plum special assignments and no support roles that become the career dead ends that drive women from the occupation.

A team intent on shoring up collective ownership should explore the engineering practices contained in Extreme Programming; pair programming, refactoring, frequent integration, unit testing and test-driven development[53].

We should note that the challenge of marginal roles is not entirely addressed by Agile practice. Roles tend to proliferate in support of the team and product owner such as “Agile business analyst” and “product owner proxy”. Whenever principled organizations place staff in such roles, they should look upon it as an expedient to deal with dysfunctions in the organization. People in these roles should have a meaningful path to empowered product owner or member of the team. The support roles should eventually go away or be shared among product owners or the team. This may take years.

6.4. Sustainable pace - an antidote for extreme work schedules.

Traditional and startup software cultures celebrate long, hard hours crashing for a deadline. The modern global distribution of business requires communication and coordination with teams in vastly different time zones. While women can feel fulfilled and challenged by extreme work schedules, they lead to attrition from the industry[54] though not necessarily any more than for their male counterparts.

Steve McConnell wrote that teams crashing for a deadline tend to “make it up” by extended recharge times afterwards. Long exhausting hours are another form of heroics and result in the same code quality and

craft issues[55]. From a principled Agile perspective, this is an anti-pattern that undermines the goals of the practice. It leads to diminished quality, breaks team cohesion, removes transparency and interrupts predictable, regular delivery.

Agile teams strive for a sustainable pace; delivering quality, complete work at a committed but humane level of effort that they can maintain indefinitely. Sustainable pace enables an organization to plan by trending to completion on the iteration and the release level[56].

6.5. Craftsmanship - an antidote for lack of meaning and social purpose.

Women, more than their male counterparts, enter STEM out of passion for the work and a desire to contribute. "63% of female scientists working in the private sector have chosen to do what they do because of a desire to contribute to society's health and well-being; this compares with 51% of their male colleagues... 74% of women in technology love their jobs[57]."

One of the main reasons young women are disinterested in computer science is belief that it offers no social benefit[58]. Agile principles elevate the status of individual contributors by connecting them to the vision of the product through collaboration with the product owner. In addition, the user experience advocacy of Jeff Patton is refining the value system to demand more respect and understanding of the end user. All this in the belief that loving your job and caring about the people who use the product should not be so unusual in software development.

6.6. Collaboration - an antidote for isolation.

The relative absence of peers, mentors and role models isolates women. Research indicates that the social aspect of Agile practice, particularly routine face to face meetings and pair programming reduces women developer's sense of isolation and raises their satisfaction and confidence[59]. It also reduces feelings of internal competition and builds trust[60].

Agile practice also brings developers into more routine contact with people from the business. This provides potential peer connection and mentorship from women in other roles such as product owners, stakeholders, and sponsors. As an example, at Oxygen Media in 2007-8, an initially all male Agile team, collaborated with their female CEO and Product Owner to develop an innovative product. As the team sought to add members, the work, the team and the product owner relationship contributed to recruiting and retaining talented and experienced women developers[61].

7. Agile values in an enterprise context

As a development team matures into high-performance, impediments become consistently rooted in the surrounding organization. Continuous improvement becomes an effort to instill values of accountability, transparency, craft, and delivery in the groups that feed the team work and address their logistical needs.

An organization that embraces Agile values strives to manage the flow of all aspects of the business as predictably and responsively as the development organization. This aligns with the Nonaka and Takeuchi model of a serially innovative, knowledge creating company. A company can adopt the Scrum framework to manage core business functions. Scrum can even be applied to businesses that don't produce software[62].

Such an organization needs to examine its pay and incentives so they support collective performance. Traditional review and reward processes can be "teamicidal". They encourage heroism, competitiveness and collaborative anti-patterns. More appropriate are incentives that reward team performance, and span of influence over span of control. The organization should move towards flatter, fairer org structures, rewarding workers without proliferating managers or creating side doors to advancement[63].

Finally, a team-focused organization has a different definition management than a traditional hierarchical one. Rather than command and control, a manager becomes a facilitator and impediment remover. Nonaka and Takeuchi describe the "middle up down manager" who actively facilitates knowledge flow from senior executives to individual contributors. This is also the "servant leader" approach where a manager's goal is to optimize the work environment so that individual contributors can perform at their best.

Done well, this addresses some of the remaining factors that drive women from software development: unfair pay, unclear path to advancement and not fitting the corporate image of a manager.

But to really address isolation, the industry needs to make a specific commitment to be more supportive of women workers:

- i. Recruit a workforce that reflects the diversity of their customer base.
- ii. Train and develop their employees so that they continue to learn and advance in their craft
- iii. Connect their mission to a larger meaning and social purpose by anchoring strategic projects to a vision and the needs of customers.
- iv. Support their employees' full range of interests and better balance work and family life.

Fortunately, these changes benefit male employees as well and facilitate the requisite variety required to make the company more responsive to its customers.

8. Academics and society

The shortage of women studying IT is the best researched aspect of the problem (Margolis). Industry focused studies (Athena) also cover issues within education.

That said, the software industry must influence expectations and outcomes in education. School environments that discourage girls from pursuing computing are a significant factor in the low numbers of women entering the IT workforce.

Here, two factors we haven't covered come into play: extrinsic gender bias and intrinsic doubt. Industry can help remedy this situation by recruiting qualified women undergraduates. This demonstrates to institutions the value in producing these applicants. Industry can also fund initiatives at all levels of education from girls math and science schools to scholarships, mentorship, special projects, after school programs and achievement prizes.

The industry can also publicly recognize successful and innovative women and convey a fascination with their work. As an example, the World Science Festival features events with prominent engineers, scientists and technologists such as Sandra Magnus, Beth Shapiro, and Heather Knight[64]. Such role models increase girls confidence in their abilities in STEM.

9. How values create change from small networks to large and back: Ba

As described, impediments that discourage women pervade the software ecosystem: within development organizations, enterprises, in education, and society. The approach Agile takes to removing impediments is incremental - inspect and adapt. Given that, how can Agile produce large order changes across and industry and society?

To model this, we will utilize I. Nonaka's concept of Ba, or "a shared context in motion, in which knowledge is shared, created and utilized[65]."

Sectors that thrive off innovation do so by sharing knowledge across direct and extended-relationships among people. Each set of relationships exists within a physical or virtual space. Each of these spaces is Ba. Ba can be visualized as sets of overlapping circles each circle representing a network of people. Tacit and explicit knowledge is created and shared across Ba as people cycle transiently or move permanently from one set of relationships to another.

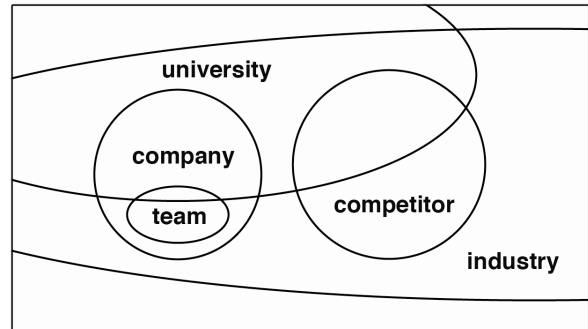


Figure 4. Ba in the Software Industry

Knowledge workers in an industry locale interact within their local communities, universities, interest groups, their individual businesses and work groups. They graduate from school and change jobs. Companies are distributed across locales. Consultants travel among companies and conferences bring individuals together from across the industry.

In sharing, creating and synthesizing knowledge one Ba influences the other, fostering change on the small scale to the large and back. The broad adoption of Agile practices is itself an example of change occurring first within individuals and teams and then spreading across an industry.

The challenge is whether mainstream Agile adoption is creating and sharing a tacit understanding of Agile principles or simply an explicit understanding of its practices. If the principles do not permeate this adoption curve, Agile will become just another toolkit and will not significantly change individual or organizational behavior.

If, however, Agile principles are embraced by the industry it will change the perception of the work culture and what it is to be a software developer. It will create a market for developers suited to that more collaborative, social way of working. Universities will adjust to provide that talent. Media focus on that success will celebrate new role models and the change will influence the larger culture.

As discussed earlier, the primacy of values is on the minds of prominent Agile thought leaders. It is infused in the Snowbird celebration "four things the community **needs to do** in the next 10 years": demand technical *excellence*, promote *individual change* and lead *organizational change*, organize *knowledge* and improve *education*, and maximize value across the *entire process*[66].

10. Conclusion

The shortage of women entering software development and disproportionate share of them leaving mid-career is real, measurable and well documented. While this has been true across STEM

disciplines, the disparity has gotten worse in software development over the last 20 years.

The resulting gender gap is a material burden to the software industry and a lost opportunity for a domestic workforce with a high percentage of workers stuck in low demand occupations.

The relative absence of women in product teams contributes to software that under-serves women. While women are the equals of men in influencing consumer technology spend and in online activity they find male designed software user experiences less intuitive, the internet less safe, and more overwhelming.

Therefore, the software industry needs to make a concerted effort to educate, recruit and retain women developers. Both for the additional resource they provide but also for the diversity of experience they bring to product development teams.

This effort finds support in the principles underlying Agile Software Development, a movement built on values of collaboration, delivery, quality and craft. The challenge for the Agile movement is that the increasing popularity of its practices does not necessarily bring with it widespread embrace of its values.

Agile values steel practitioners for the hard work of confronting impediments, incrementally nudging an organization towards a more collegial, sustainable, creative and productive workplace so that the organization can repeatedly create software of value to stakeholders and of real use to people.

Success within teams has potential to shift the larger culture through iterative cycles of knowledge creation and sharing within companies, across enterprises, into academic institutions and the media.

In this way principled Agile practice can instill a more social and engaged view of the software developer that will encourage girls to pursue computer science and help the industry recruit and retain larger numbers of talented women.

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