Cross-Functional Teams: Learning from Industry to Identify Opportunities in Undergraduate Education

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Abstract - Universities often speak of "multidisciplinary" or "interdisciplinary" teams in ways that are rooted in our understanding of departmental and disciplinary structures. Industry, however, more often refers to "cross-functional" teams, reflecting a slightly different organizational structure. While there are a number of parallels across these concepts, the cross-functionality of industry teams presents several unique barriers that undergraduates – even those with multi/interdisciplinary experience – may not be adequately prepared for.

To address this gap, this paper presents findings drawn from both a literature review on cross-functional teaming and a case study of cross-functional teams in a large consumer-products manufacturing firm to identify key learning outcomes for undergraduate students. In particular, the paper focuses on students' abilities to negotiate the kinds of structural barriers posed by cross-functional teams. These barriers can include complex reporting and hierarchy systems, physical separation of team members that limits informal exchanges of ideas and information, lack of clear communication channels among team members, and lack of communication channels between team leaders and the leaders of the functional units.

Keywords: Teams, teamwork, interdisciplinary, cross-functional, workplace

INTRODUCTION

When new engineers shift from academia to industry, they face a working environment that differs significantly from the typical undergraduate departmental system. In the academic setting, most engineering students enjoy a high level of familiarity with their classmates, work on small co-located teams, and operate under relatively simple hierarchical organizational structures. In many contemporary engineering workplaces, in contrast, new graduates are likely to encounter cross-functional teams that involved distributed or even virtual collaboration, complex hierarchical structures with convoluted reporting lines, and simultaneous participation on multiple and/or very large teams. Given the persistent government and industry demands for strong teamwork skills in new graduates [16, 17, 6], engineering faculty can enhance student education and facilitate students' transition to the workplace by better understanding the nature of contemporary teamwork and the expectations faced by new graduates.

To help educators better prepare students for the complex team dynamics of the workplace, this paper combines a literature review of industry practices with a case study of the experiences of practicing engineers in a large consumer manufacturing organization that recently shifted from a more traditional hierarchy to a cross-functional structure.

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LITERATURE REVIEW: CROSS-FUNCTIONAL TEAMS IN INDUSTRY

Much of the current literature on teamwork in engineering classrooms centers on specific behaviors within a team (team roles, team composition, team interactions) that promote team success [5, 11, 28, 19, 30, 20]. Recent engineering education research also points to some attention to multidisciplinary and/or multicultural teams [8, 18, 7, 4, 24, 25] and virtual teams [8, 26, 3, 32, 22]. Few, if any, of these discussions, however, have considered how to prepare students for the larger organizational structures associated with cross-functional teams that significantly impact team and individual performance.

Cross functional teams typically involve a matrix structure that ties together essential elements of an organization's functions. That is, companies may be organized into functional units (design, manufacturing, marketing, etc.), but in a matrix organization, product development teams pull together individuals from each of these functional units – hence the term "cross-functional team." Research literature is replete with matrix theory and organizational models that describe varying conditions that teams face. Of these conditions, three emerge as particularly important for new graduates:

- Distributed work environments
- Organizational Structure and Lines of Reporting
- Multiple Team Participation

The following sections describe these conditions in more detail

Distributed work environments

New engineering graduates have typically worked exclusively or primarily on design teams that have the luxury of co-location – that is, sharing the same physical workspace with their collaborators. Co-location certainly simplifies communication; dealing face to face always provides communication cues to meaning that voice only or e-mail communications cannot. However, depending on the industry, products, type of company, among other variables, co-location in the industrial setting may not be possible. It is plausible that team participation will be at least distributed if not entirely virtual. Importantly, Hoegl et al. note that distributed work environments may exist even though the team members are in different floors of the same building or in different buildings of the same business campus [9].

Such distributed environments, even over very short distances, increases the importance of teamwork, collaborative processes, and project management skills, and add additional complexities. For example, in considering the types of skills required for such teams, Malhotra et al. presented a case study of an entirely virtual product development team consisting of Boeing and Rocketdyne members [12]. To successfully deliver the new product, they identified three team needs: creating a shared understanding, frequent interaction employing communication ground rules, and the rapid creation of context-specific knowledge, all of which may be new to engineering graduates. Chinowsky also studied virtual project teams and established two conditions for successful outcomes [4]. The first was modification of existing protocols and standards for application to virtual projects. Agreement on these modified protocols needs to be in place prior to the start of the project. Second, the team needs to be empowered to make independent decisions, as this will reinforce the team function and focus. Each of these practices may be unfamiliar to new graduates whose primary experiences have been with co-located teams, yet they are vital to successful workplace practice.

As noted, distributed and virtual work teams are one area of teamwork that has seen at least some attention in engineering education in recent years [8, 26, 7]. Elsewhere, drawing on both prior literature and case studies of student virtual teams, Paretti and McNair have identified core competencies such as developing trust and establishing relational space [23, 14, 22], but clearly more work remains to be done in considering how best to prepare engineering students for distributed collaboration.

Organizational Structure and Lines of Reporting

In addition to learning to work in distributed environments, however, students must also learn to function in complex organizational structures that can differ significantly from the more monolithic departmental structures students are familiar with. Increasingly, organizations are adapting various forms of matrix structures. Organized typically by functional departments (i.e., R&D, engineering, operations, manufacturing, sales), firms are creating cross functional teams that combine representatives from pertinent departments. Cross functional teams can speed product development and improve the efficiency of an organization. As a result, recently graduated engineers will likely enter an organizational structure that is far more complex than an academic department. This complexity brings a host of social and subtle political pressures to bear that probably are not operative in design class settings.

In a traditional functional organization, the engineer is located within the functional department such as design, manufacturing, or quality control, and takes direction from the functional manager who oversees a group of people with similar, or at least related, skills and responsibilities. As cross functional teams are formed, significant time and effort may be spent with representatives from other departments, including not only other types of engineering sectors but also business, finance, marketing, and industrial design.

One key aspect of these teams that may be unfamiliar to students coming from traditional departments is the importance of developing trust and personal relationships, which is widely quoted as critical to the success of cross functional teams [13, 12, 1, 10]. Miller found that "traditional functional boundaries blur when a cross functional team is interacting effectively." Team members lose their functional departmental perspectives, replacing it with "concern with what is best overall for the project and the company" [15].

Similarly, with the increased speed and efficiencies come additional complications in terms of organizational hierarchy. To whom does the recently graduated engineer owe allegiance; to the engineering manager or the team leader? From whom does the engineer take direction? Since each engineer typically reports hierarchically to the engineering manager, this manager's attitude toward cross functional teams may be critical to an individual engineer's ability to effectively participate on a team. Managers that prefer more traditional organization structure and/or explicitly disagree with the use of cross functional teams may discourage new engineer from being open and honest with the team. Few new graduates are skilled at navigating such interpersonal complexities, yet the ability to trust and be trusted by one's team members is critical; interviewees in Miller's study [15] said that "Nothing kills trust faster than suspecting that a team member is advancing a hidden agenda to protect his/her departmental turf."

Annual performance reviews present another issue that gets caught in the matrix organization with potential conflicts between the functional departments and cross functional teams, and can leave new graduates particularly vulnerable. Who reviews the recently graduated engineer—the team leader or the functional manager? Sethi [27] defined a "charged team" as one that is highly driven to superior market performance. He suggests that having individual evaluations tied to team performance "seems to increase the likelihood of charged behavior." That could lead one to believe that the team leader should perform the evaluation.

One difficulty with the team leader being responsible for personnel reviews, however, stems from the duration and extent of an engineer's participation on a projects (or projects). There is a continuum of short to long projects and participation on multiple projects versus a single project. Should the project be of short duration or the engineer in question be participating on multiple teams, the focus on the functional department is reasonable. So, the entity performing the personnel review may be one of several (team leader, team leaders, functional manager, or a combination). In any event, the responsibility for personnel reviews may not be immediately clear to the recently graduated engineer.

Interestingly, while Sethi [27] found team based personnel evaluations to be important to encourage charged team behavior, other researchers have found that this may not be the case, depending on the circumstance. Bonner [2] performed a cross-sectional study and attempted to correlate team versus individual rewards with successful team performance. He could not support the correlation with his research. Vadapalli [31] found that a lack of team/project based reward did not inhibit team performance. This conflict in research conclusions possibly reflects the wide variation in team composition, objectives, and protocols.

In short, succeeding in cross-functional team environments requires new graduates to move beyond traditional conceptions of teamwork such as Meyer's-Briggs or similar personality-based team dynamics, Belbin's team roles, or Tuckman's team phases. They also need skills in distance collaboration and organizational analysis to understand and negotiate structural dynamics.

Multiple Team Participation

Finally, young engineers will likely have to learn to develop a high degree of flexibility regarding team participation. Most students' experiences with teams have most likely been as part of a small stable group of fellow students. But depending on the particular industry, company, and product type, new engineers may work on a single long term project, such as a design-build capital construction project team, or on many shorter term product development teams, sometimes concurrently. For example, in a study of 12 global corporations, Soederquist [29] investigated knowledge management within companies. His findings indicated that companies can (and do) improve knowledge transfer through job and team rotations. This takes place in one of three modes: transfer of personnel from completing to starting projects, job rotation within a project organization, and rotation of the project manager responsibilities between team members from differing functional groups. Employing these methods expand the organization's knowledge sharing and encourage bottom-up initiatives. But while such knowledge sharing can benefit companies in the long run, the changing and interchangeable nature of industry teams means that new engineers need to learn how to readily adapt to and learn within a shifting set of team environments.

In addition, Olson [21] found that the patterns of participation between functional departments varied, depending on the stage of the project. Olson studied the development of 34 new products and established that collaboration between R&D and marketing was critical early in the project. Later in the projects, cooperation between operations and marketing was significantly related to project performance. Therefore, new engineers may become involved with a team whose membership is not consistent over the life of the project, and students will need to develop skills that allow them to readily transition such working relationships.

Finally, as with cross-functional teams, dynamic teams demand a high degree of rapid interpersonal learning. Researching large dispersed engineering design teams, Larsson investigated the need for developing social capital [10]. He defines social capital as consisting "of the stock of active connections among people; the trust, mutual understanding, and shared values and behaviors that" make cooperative endeavors possible. Larsson's central concept has application here. That is, on any large team, it is critical to discover those individuals that can be counted on for reliable information; in Larsson's terms: "know who knows", "know who to trust", and "know who to ask". The "Know-Who" element of operating within a large team is likely a concept with which the recently graduated engineer will be unfamiliar.

Summary

Research literature, then, informs us of at least three areas with which the recently graduated engineer will have minimal experience. First, teams on which the engineer may participate may be dispersed, with little face-to-face contact. This will amplify communication and interaction issues. In fact, it is very possible that the team will be completely virtual, further aggravating the communication challenges facing the engineer.

Second, cross-functional teams, as a subset of matriced organizations, present such issues as power struggles between the functional manager and the team leader/organization. Dual lines of reporting, to the team leader and functional manager, may place the recently graduated engineer into an awkward position. The engineer may be forced to cope with conflicting direction between the functional manager and team leader. This hypothetical, but potentially real, condition could become problematical during personnel reviews.

Finally, new engineers typically work in teams with a relatively small group of people that may have or can quickly form collegial relationships; in smaller departments, students may also know each other quite well prior to working in teams. Engineers shifting to industry settings may be assigned to multiple part time teams. This places engineers in situations in which an understanding of other team member capabilities cannot be established organically, as was possible with student design teams. Coping with this situation will present the recently graduated engineer with unexpected unknowns. Developing the mechanisms for understanding and dealing with this situation will take time; particularly should the engineer be unprepared for it.

CASE STUDY METHODOLOGY: CHARACTERISTICS OF CROSS-FUNCTIONAL TEAMS IN INDUSTRY

Case study approach

To extend the work of prior researchers and more fully explore the teamwork skills required in cross-functional teams in the contemporary workplace, we conducted a case-study at a larger consumer-goods manufacturing company that was in the process of implementing a cross-functional product development approach. Yin (Yin 2003) defines three conditions that merit case study research: 1) the nature of the research question is typically explanatory, exploratory, or descriptive, typically structured "how" or "why"; 2) the investigator lacks methods to control the site and participants; and 3) the phenomenon being studied is contemporary and the context is real-life (pg. 1); Table 1 maps these conditions onto the present study.

Table 1: Case study criteria mapped to research conditions

Conditions	Research Setting
Nature of the research question	The research is an exploratory question to more fully understanding the teamwork skills required to shift from traditional unit-based hierarchies to complex cross-functional teams.
Lack of control	The researcher had no control over enrollment and outside factors that could influence professionals' behaviors in the cross-functional team process.
Contemporary phenomenon in real-life context	Cross-functional teams are a contemporary phenomenon in industry and were studied *in situ* in a real industry context.

Research setting: Industry team in transition

The case study focuses on a cross-functional team in a consumer-goods manufacturing company. The company was in the process of moving from a more traditional unit-based organization (engineers with engineers, marketers with marketers, and so on) to a cross-functional approach that brought leads from all core areas (e.g., design, marketing, finance, manufacturing, supply) together from the beginning of the project. The company adapted one of several widely used approaches to cross-functional teams. The case study followed the team for approximately twelve months, with four site visits to interview participants.

Data collection

As noted, data was collected during four site visits; the study relied primarily on interviews with team members and area leads. Semi-structured interviews were used to probe subjects' experiences with the cross-functional structure, the communication patterns at work, and the nature of the collaborations. Of particular interest was the relationship between the recommended guidelines for the approach and the realities of practice. Field notes and observational data were used to supplement the interviews. The study was conducted with approval from the Institutional Review Board to insure appropriate ethical treatment of human subjects in research (IRB # 06-045).

Data analysis

The analysis of the interview and observational data followed an open-coding approach (Strauss and Corbin 1998) to find emerging themes. Following open-coding procedures for verbal data (Glaser and Strauss 1967; Miles and Huberman 1984; Geisler 2004), responses were segmented into coherent units of thought; segments were then examined for a central theme, themes were compared, and similar themes were grouped together. The relevant dominant themes were then used to recode all data, and the codes were validated by a second researcher. Comparisons were used to refine the definitions, and points of discrepancy were resolved. In this case, two sets of codes were applied to the data: attitudes and organizational structures. Table 2 summarizes the codes used for analysis.

Table 2: Codes for Analyzing Cross-functional Industry teams

Category	Code	Definition
Attitude	Negativity	Statements that pertain to negative attitudes associated with cross-functional/matrix structures (e.g. discomfort)
	Flexibility	Statements that describe the need for flexibility
Team Structure and Focus	Changing Teams	Statements that describe employees having to work with new (and constantly changing) groups of individuals, possibly several different groups at once.
	Role Shifts	Statements that describe changes in individual roles and responsibilities associated with the matrix structure
	Scope	Statements that describe the need to develop perspective across the entire project cycle, and by implication, the corporation rather than focusing solely on their individual functional department.

CASE STUDY FINDINGS: CHARACTERISTICS OF CROSS-FUNCTIONAL TEAMS IN INDUSTRY

The analysis of the qualitative data resulted in two primary themes that incorporated five codes (Table 2). These codes provide perspective on the interviewee's attitudes, feelings, and thinking, as this particular organization shifts from a functional structure to a cross functional team based structure. The shift represents a challenge for those involved in the shift.

Attitude

The first theme developed from the data is associated with team member attitudes about pending change. Here, data analysis resulted in two codes associated with attitude. For some team members, the shift to cross functional teams is disruptive. Moving away from the comfortable familiar functional organization is meeting resistance. Individuals were not comfortable with this change and voiced their opposition. This opposition took on an attitude of "Negativity".

Conversely, some individuals alternately voiced the need for flexibility and indicated a willingness. Some individuals, uncomfortable or not, recognized that the older form of the organization had severe limitations. The old order needed to change; it did not function well. Even for individuals feeling that change was difficult, it was recognized as essential. This coding recurred as "Flexibility" in attitude. Table 3 presents sample data to illustrate both "Negativity" and "Flexibility".

Table 3: Sample "Attitude" Data

Negative Attitude	Flexible Attitude
[Late Project Interview] ...we went from this structure where this is the person you report to …to this structure where you gotta kinda make both of these people happy. [Late Project Interview] ...I'd rather go back to the old way where I was always working on, you know, [a particular type of] product. [Late Project Interview] …they want to, you know,	[Early Project Interview] …[the newly structured meeting has] been more comfortable for me in that, I feel like there is a little more discipline on the business side. [Early Project Interview]…perhaps a lack of coordination across projects-from the tech side. Not clear who is prioritizing projects and determining what projects get work resources. [Late Project Interview]] I've been at a meeting

launch and leave...it was more comfortable. [Late Project Interview] …the team was smaller and they didn't have as much to worry about I think.	where we've gone in, tell the customer about a new product and then [another guy—same company] would and say you don't want this one, you want that one…We're not working together very well.

Team Structure and Organizational Focus

This second theme represents team member concerns and reactions in dealing with a cross functional team structure. The first code, "Changing Teams" examines the challenge facing team members, who previously dealt only with their functional department. Being forced from the familiar, they were now confronted multiple new tasks, new people, and new routines. To confound this, team changing will be recurring indefinitely with the new organizational model. With one assignment completed, the team disbands, members are dispersed, and new sets of teams, with new sets of members, with new tasks and objectives are formed. A future of constant change bodes concern for groups of people familiar only with a limited set of people and tasks surrounding them.

As the organization shifts from functionally based to a cross functional basis, roles and responsibilities will necessarily shift. For example, lead supervisors and managers in a functional role may shift to cross functional team leaders, a role that did not previously exist. This forces a paradigm shift both for people, who may have known the individual for years in the functional setting and for the individual, who is now attempting to direct a team of unfamiliar people in an unfamiliar direction. "Role Shifts" describes individuals confronting changing definitions of their individual purpose within the organization.

One attribute of an effective cross functional organization is that team member's scope of understanding expands from the functional department to the cross functional team and project cycle, and then, by implication, the corporation. Focus shifts from a colloquial set of functional activities to the broader project cycle, involving many departments. The process describing the development of an expanded more holistic view is summarized by the code "Scope". Table 4 provides sample data that reflect attitudes associated with "Changing Teams", "Role Shifts", and "Scope".

Table 4: Sample "Team Structure and Organizational Focus" Data

Changing Teams	**Role Shifts**	**Scope**
[Late Project Interview] …depending on how much work load is required for that project, they may say this guy's also working on a project for Jen and working on it for Keith part time. [Late Project Interview] ...you know, you're going to work on this one for a couple weeks, then you gotta go back to {another] one. In the past, that wouldn't happen. [Late Project Interview] …we're gonna be designing that [one product] and … you're gonna work on [another] team. And I imagine there's some uncomfortableness, you know, with that.	[Early Project Interview] I've been doing this for so long that people are having a hard time putting me into a different role. [Early Project Interview] But I think you gotta be careful what your role is in an organization, and, make sure you do what your core job is. [Late Project Interview] … he's kind of had to transition more to the project leader. [Late Project Interview] …they didn't really have project leaders before. You had like a [departmental] team and a technical team. …it wasn't cross functional.	[Early Project Interview] …was saying engineers need to be more understanding of sales and marketing well it works both ways. [Late Project Interview] …we were just kind of throwing it over the wall a little bit. [Late Project Interview] ...and right now we're doing a pretty good job of working together and making sure we're not dropping anything. [Late Project Interview] …and you have, you know, [an] enterprise meeting across the whole corporation basically.

Conclusions

The research literature review and the results of the case study both portend significant adjustments for a recent engineering graduate entering an industry setting. The pressures of competition are forcing industry to shift from functionally based to more agile and efficient cross functional team-based organizations. Individuals on cross functional teams face challenges that will be new to recently graduated engineers who are primarily familiar with small comfortable design teams. Indeed, as evidenced in the case study, even experienced engineers, comfortable with their functional organization, expressed concerns with the shift to cross functional teams.

These challenges result from individuals being forced from comfortable familiar routines into an environment replete with change. Continuously changing teams, adjusting to new roles, and coping with complex organizational structures and reporting structures are conditions with which cross functional team members must deal.

These challenges all represent issues with which industry is actively grappling. They will be reflected onto the workforces representing the organizations and, importantly, they will be reflected onto recent engineering graduates whether or not they have been prepared for it.

Implications for the Classroom

The recently graduated engineer will need to develop an understanding and methods of coping with cross functional teams. To succeed at this, exposure to other disciplines, both technical and non-technical needs to occur. Technical fields could include not only the many differing engineering disciplines, but other fields of science, such as physics or chemistry. Clearly, depending on the specific organization or product, interfaces with a variety of science backgrounds could be possible.

To successfully function in industry the engineer will also need to deal with numerous non-technical fields. On a given project, this could include business cost and scheduling controls, quality, safety, field and plant operations. The awareness of and input from these organizations is critical in industry. For many of these fields “the best technical solution”, which engineers are trained to develop are not particularly important. Internalizing the concept that other disciplines may not necessarily value the “best technical solution” could be pivotal in developing relationships personnel working in those non-technical fields.

Engineering education will need to shift to be more inclusive, more holistic. Students need to specifically consider multidisciplinary or cross functional problems. Cross functional problem studies could include hypothetical table-top problems. This technique is widely used in industry to allow various mixes of personnel backgrounds to try out problems and develop solutions and outside their expertise. Broadening the student to preferably understand, or minimally be aware, of other professions and fields, as they relate to actual cross functional problems will improve their preparation for their role in the engineering profession.

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