# TEAMWORK EFFECTIVENESS FOR SUCCESSFUL PRODUCT DEVELOPMENT:
# RELATIONSHIP BETWEEN ENGINEERS AND INDUSTRIAL DESIGNERS

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# ABSTRACT

TEAMWORK EFFECTIVENESS FOR SUCCESSFUL PRODUCT DEVELOPMENT:
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Manufacturing companies are searching for new techniques day by day to launch qualified products with a competitive price to the market. Companies believe in the importance of teams which have members coming from different disciplines who use their knowledge, experiences, and creativity for achieving the goals of their teams.

The purpose of this study is to explore the effectiveness of teamwork for successful product development process by focusing on the relationship between the team members –especially engineers' and industrial designers' relation. After a broad literature survey, a descriptive-survey study that aims demonstrating the relationship between engineers and industrial designers in manufacturing companies in Turkey is held in order to investigate the effectiveness of teamwork in product development process. A twelve item questionnaire which has four open-ended questions and eight Likert-scaled statements has been prepared. As the result of this study, a positive relationship is found between the performance of product development team and the effects of cooperation, social and professional communication, having clear and common goals, sharing knowledge and experiences, leadership, coordination and cooperative problem solving and decision making processes to the relationship between engineers and industrial designers.

Keywords: teamwork effectiveness, product development, cooperation, engineering, industrial design

# ÖZ


## ÜRÜN GELİŞTİRME SÜRECİNDE TAKIM ÇALIŞMASININ ETKİNLİĞİ: MÜHENDİS – ENDÜSTRİYEL TASARIMCI İLİŞKİSİ

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Üretici firmalar, pazara kaliteli ve rekabet edilebilir fiyatlarla ürün sürebilmek için sürekli olarak yeni teknikler araştırmakta ve farklı disiplinlerden bireylerin bir araya geldikleri ürün geliştirme takımlarının etkinliğine inanmaktadırlar. Bu takımların üyeleri, takım amaçlarına ulaşmak için bilgi, deneyim ve yaratıcılıklarını kullanırlar.

Bu tez çalışmasının amacı, başarılı ürün geliştirme sürecinde takım çalışmasının etkinliğinin, aynı ürün geliştirme takımında görev alan mühendis ve endüstriyel tasarımcıların ilişkileri açısından araştırılmasıdır. Bu doğrultuda, geniş bir literatür taramasının ardından, ürün geliştirme sürecinde takım çalışmasının etkinliğinin, Türkiye'deki üretici firmaların ürün geliştirme takımlarında yer alan mühendis ve endüstriyel tasarımcıların ilişkisi üzerine örneklemini 14 mühendis ve 14 endüstriyel tasarımcının oluşturduğu bir anket çalışması yürütülmüştür. Bu anket calışmasında dört açık-uçlu ve sekiz Likert-derecelendirmeli olmak üzere toplam oniki adet soru yönlendirilmiş ve çalışmanın sonucunda, ürün geliştirme takımının performansı ile mühendis ve endüstriyel tasarımcı ilişkisinde işbirliği, sosyal ve mesleki iletişim, net ve ortak amaçlara sahip olmak, bilgi ve deneyim paylaşımı, liderlik, koordinasyon ve işbirliğinde problem çözme ve karar verme gibi konuların doğrudan bağlantılı olduğu saptanmıştır.

Anahtar Kelimeler: takım çalışması etkinliği, ürün geliştirme, işbirliği, mühendislik, endüstriyel tasarım

To My Parents

# TABLE OF CONTENTS

# LIST OF TABLES

TABLES

# LIST OF FIGURES

FIGURES

# CHAPTER 1

## INTRODUCTION

### 1.1 Background to the Problem

Companies producing industrial products are constantly searching for new techniques to improve the quality of their goods, to lower the costs and to extend the life cycle of products. Concurrently, product development process is increasing in complexity while the competition in the market is getting fierce among the companies. To be leader in the market, a company must be able to offer the right product at the right time, at a high quality level with a competitive price. Meeting the customer requirements sufficiently means having a mechanism that can capture their demands and translate them to technical requirements and specifications on the product. A company should find a way to develop a product that meets customer needs better than the other companies and should launch it faster and more efficiently (Barton and Wheelwright, 1995). Therefore, many companies are aware of the importance of teams which have members from different disciplines. Each member of a team uses his/her knowledge, experience, and creativity for achieving the goals of his/her company. So it can be said that companies form 'product development teams' specifically for being competitive in their sector.

Product development is not only a technological fulfillment, but also a creative, interactive problem solving process. As Rainey (2005) states, new product development requires a collaborative work. Namely, team work is an organizational approach established to achieve collaborative behavior in highly interactive product development. Product development team usually includes participants from engineering, design, technical, marketing, sales, support, production, process development, quality, and finance departments. Participants contribute their expertise and knowledge to a balanced approach to making decisions (Rainey, 2005). These participants come together to find answers and to get agreement on such questions; “What features do customers want? How do features translate into sales? Is the technology available to develop the features? Will the product be manufacturable at the desired price?” (Barton and Wheelwright, 1995, p.244)

Rainey (2005) expresses that product designers design and develop product specifications according to the customers’ needs, including material and dimensional requirements. After this process, they pass their designs to manufacturing engineers for detailed process-plan development. Historically, designers were familiar with marketing and production perspectives in uncertainty. The consequence of the process was a “we design it, you build it” attitude towards manufacturing function. This attitude brought a number of problems in manufacturing process like: “products with tolerances that were difficult or impossible to hold with existing machine capability; components that were difficult to assemble; and products which met neither marketing expectations nor customer needs” (Rainey, 2005, p.424). As Rosenthal (1990) says, “The need for more coordination and collaboration among people who design products and those who must manufacture them had become apparent” (as cited in Ettlie and Stoll, 1990, p.22). As a result of these shortcomings, team work approach was developed to allow all departments to communicate earlier in the design process.

According to Ettlie and Stoll (1990), it is obvious that in the phase of product and process design, engineers and industrial designers are only two of the key players for a successful product development.

> A producibility engineer… uses as inputs designs from design engineering and capabilities observed in the factory, then converts

> those designs and capabilities into workable designs so they can be made in the factory. The producibility engineer, then, is a compiler of information, an optimizer of factory input and design input into producible scheme. (Koenig, 1987 as cited in Ettlie and Stoll, 1990, p.37)

According to Ettlie and Stoll (1990), there are a number of well-accepted reasons why design and manufacturing do not fit like hand and glove without a great deal of effort. The culture of the two functions is different and corporate expectations for the two are not the same. At that point, necessity of teamwork effectiveness comes into prominence.

Recently an increasing number of studies in the related literature explore the importance of team work for a successful product development. According to these studies, for an effective teamwork, some of the core points are; importance of communication, collaboration and cooperation, coordination, effectiveness of leadership, team-learning, emphasized team goals, importance of problem-solving and decision making, and so on.

## 1.2. Purpose of the Study

The purpose of this study is to explore the effectiveness of teamwork for successful product development process by focusing on the relationship between the team members –especially engineers' and industrial designers' relation.

Major research question of this study is;

What are the factors influencing the effectiveness of teamwork on the success of product development processes carried out by teams especially having both engineers and industrial designers as members?

The study also serves for finding answers for following questions:

What are the aspects of teamwork influential on the product development processes?

By considering the teamwork aspects, how does the relationship between engineers and industrial designers affect the teamwork success in product development processes?

What does the term ‘teamwork’ refer to for the companies having product development teams in Turkey and what are the characteristics of those groups so-called ‘product development teams’?

By considering the ones who are the members of the product development teams of the companies in Turkey, what are the engineers’ and the industrial designers’ opinions about teamwork approach, their roles and relations in teamwork processes, and the effects of teamwork aspects to their success?

## 1.3 Structure of the Thesis

With the purpose of finding answers to these questions a broad literature review was executed. Next chapter presents results of the literature review study.  In the third chapter, the methodology and the limitations of the survey study examining teamwork effectiveness on product development teams especially focusing on the relationship between engineers and industrial designers are given. Fourth chapter presents the results of the survey.

In the final chapter, the findings of the literature review and the results of the survey are evaluated. Additionally, suggestions for further research are communicated in this chapter.

# CHAPTER 2

## REVIEW OF THE LITERATURE

This chapter elaborates effectiveness of teamwork in companies and in product development process. At the outset, the differences between terms of teamwork and group work are investigated. Roles of the product development team members are presented concerning the relationship between industrial designers and engineers. Perceptual gaps between those disciplines are pointed out. Finally, some of the factors affecting team success with the concern of industrial designers and engineers are presented.

Related literature was scrutinized between 1993-2006 by using certain keywords such as; teamwork, multi-functional teamwork effectiveness, product development, product innovation, cooperation, collaboration, co-ordination, communication, team-learning (learning team), leadership, industrial design and engineering in METU, Bilkent University, and YÖK (Higher Education Commission) Libraries, and in some leading databases like EbscoHost, Wiley InterScience, ASEE, Blackwell Synergy, Science Direct, and so on.

### 2.1 Teamwork in Companies

Developing and producing reliable and effective products need professionalized work at the product development stage in industrial production. Companies believe in the importance of teamwork and its formation which directly affect the success of product development stage.

### 2.1.1 General Definitions of Teamwork

Recently, teamwork is getting more and more emphasized and being studied by many authors and discussed in various articles. Researchers usually define and emphasize particular points of teamwork such as the importance of common goal and target; and the importance of cooperated work of a group of people.

As one of the purposes of this literature review study, in order to comprehend it deeply, some of the noteworthy definitions of teamwork are compiled as follows;

> A team is a group composed of limited number of people who have complementary abilities, a common goal, performance objectives and collective approaches that they deem one another as mutually responsible (Katzenbach and Smith, 1993 as cited in Arsal, 2003, p.2)

> A team is a collection of individuals who exist within a larger social system such as an organization, who can be identified by themselves and others as a team, who are interdependent, and who perform tasks that affect other individuals and groups (Guzzo and Dickson, 1996 as cited in Stewart, Manz, and Sims, 1999, p.307).

> Organizations have come to rely on team-based arrangements to improve quality, productivity, customer service, and the experience of work for their members (Guzzo, Salas, and Associates, 1995, p.1).

> Team is a group of people that perform similar works, voluntarily gather together to analyze the problems and to create solutions and present them to the management. In other words, team is the place where collective ideas are generated. The employees undertake responsibilities for quality and productivity execute the works and develop their abilities and skills in line with the expectations of the organization (Gustafson and Kleiner, 1994, p.17).

> A team is a group of people who are interdependent with respect to information, resources, and skills and who seek to combine their efforts to achieve a common goal (Thompson, 2004, p.4).

As these definitions show, teamwork has some significant characteristics. Almost all the definitions are similar to each other but their ways of describing general properties of teamwork, such as its advantages and disadvantages vary according to different authors. These variations will be mentioned in the following sections.

### 2.1.2 Group Work

Group work is another type of collection of individuals for achieving certain goals. Although there are some similarities between teamwork and group work, there are some specific differences between them too:

> A group is normally defined as two or more people who interact in some way. While this distinction between teams and groups makes some sense, it is impossible to clearly determine the point where a group becomes a team (Stewart et al., 1999, p.3).

> People join groups in order to achieve goals they are unable to achieve by themselves. A group may be defined as a number of individuals who join together to achieve a goal. It is questionable whether a group could exist unless there was a mutual goal that its members were trying to achieve (Johnson and Johnson, 1994, p.10).

In the literature, there are some different definitions found about group work:

> A *working group* consists of people who learn from one another and share ideas, but are not interdependent in an important fashion and are not working toward a shared goal. Working groups share information, perspectives, and insights, make decisions, and help people do their jobs better, but the focus is on individual goals and accountability (Thompson, 2004, p.4).

> Working group is a group for which there is *no significant incremental performance need* or opportunity that would require it to become a team. The members interact primarily to share information, best practices, or perspectives and to make decisions to help each individual perform within his or her area of responsibility. Beyond that, there is no realistic or truly desired “small group” common purpose, incremental performance goals, or joint work-products that call for

either a team approach or mutual accountability (Katzenbach and Smith, 1993, p.91).

According to Schermerhorn et al. (1997), groups consist of two or more people who have common goals. Members of the group come together only for some certain goals.

There are two contrary approaches of group work according to Johnson and Johnson (1994). One is the group orientation, and the other one is the individualistic orientation. Johnson and Johnson summarize some opinions of researchers who are interested in this subject. The group orientation concentrates to the ‘group’ as a whole. Emile Durkheim (1898) stated, “If, then, we begin with the individual, we shall be able to understand nothing of what takes place in the group” (as cited in Johnson and Johnson, 1994). On the contrary, the individualistic orientation concentrates to the ‘individuals’ in the group. According to Floyd Allport (1924), each attitudes, cognitions, and personalities of the members assesses the function of the group (as cited in Johnson and Johnson, 1994). After Allport’s approach many social scientists agreed this approach. Solomon Asch (1952) defines groups like water. He argues that, the characteristics of water belong to its elements, hydrogen and oxygen (as cited in Johnson and Johnson, 1994). According to him, this knowledge is alone, however, is not sufficient to understand water – the combination of hydrogen and oxygen must be examined as a unique entity. Consequently, groups should be studied as “unique entities”, but also considering by characteristics of the group members.

### 2.1.3 Differences between Team and Group

According to Katzenbach and Smith (1993), individuality is important in working groups. Individual roles, tasks, and responsibilities are important purposes of group workers. They notice that working groups give importance to individual outcomes and results. Members of working groups compete with one another according to their individual goals. They do not take any responsibility of the other group members. Teams are different than groups. They require both individual and mutual accountability.

> Teams rely on more than group discussion, debate, and decision; on more than sharing information and best practice perspectives; on more than a mutual reinforcing of performance standards (Katzenbach and Smith 1993, p.89).

Katzenbach and Smith (1993) prepared a framework that is called “team performance curve”. This curve has five key points; each shows the effectiveness of working group, pseudo-team, potential team, real team, and high-performing team. Working group is determined as a group for which there is *no significant incremental performance need* or opportunity that would require it to become a team. Pseudo-team is expressed as a group for which there could be a significant, incremental performance need or opportunity, but *it has not focused on collective performance and is not really trying to achieve it.* Potential team is defined as a group for which there is a significant, incremental performance need, and *that really is trying to improve its performance impact.* Real team is described as a small number of people with complementary skills who *are equally committed to a common purpose, goals, and working approach for which they hold themselves mutually accountable*. Lastly, Katzenbach and Smith (1993) denoted high-performing team as a group that meets all the conditions of real teams, and has *members who are also deeply committed to one another’s personal growth and success*.

According to Katzenbach and Smith (1993) there are two sets of vital signs that indicate whether any specific group of people is a real team.

> The first set of signs includes the elements in the definition of a team – the team basics. Whenever any are missing or not quite right, the group can and should confront them directly, and work on getting them right. The second set of vital signs – themes and identity, energy and enthusiasm, event-driven histories, personal commitments, and

> performance results – includes equally powerful indicators of whether any particular group is team (p.107).

Table 1. Comparison of teams and working groups (Katzenbach and Smith, 1993, p.214)

| **Criteria** | **Working Group Characteristics** | **Team Characteristics** |
|---|---|---|
| Leadership | Strong leader | Shared leadership |
| Accountability | Individual members | Mutual and Individual |
| Purpose | Identical to organizational goals | Team purpose formed by team |
| Skill Level | Functional and established, sometimes complementary | Complementary, sometimes underdevelopment |
| Interaction Style | Structured, efficient meetings with reports and agendas | Open-ended discussions, active problem-solving meetings |
| Work-products | Individual | Collaborative |
| Productivity criteria | Sum of best performance of individuals | More than some of its contributors performances |
| Effectiveness measure | Indirect influence on company performance – goals (productivity, financial etc.) | Direct evaluation of collective work product |

Katzenbach and Smith (1993) compared teams and groups in Table 1.

Correspondingly, Susan A. Wheelan (1999) is studying on the creation of effective teams and she has similar viewpoints with Katzenbach and Smith.

> A work group is composed of members who are striving to create a shared view of goals and to develop an efficient and effective organizational structure in which to accomplish those goals. A work group becomes team when shared goals have been established and effective methods to accomplish those goals are in place (p.3).

### 2.1.4 Types of Teams

Teams are categorized in various ways. Some researchers classify teams on the basis of their objectives. Robbins and De Cenzo (1998) categorize teams as functional teams, problem-solving teams, self-managed teams, and cross-functional teams (Figure 1).

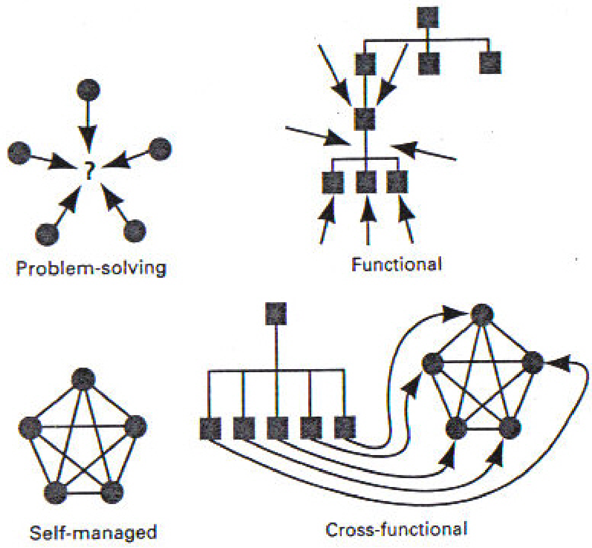



Figure 1. Types of work teams (Robbins and De Cenzo, 1998, p.336)

*Functional Teams* are formed from one manager and his/her employees. Team is involved in efforts to improve work activities or to solve specific problems within the particular unit.

*Problem-Solving Teams* are formed by five to twelve hourly employees from same department. They discuss ways to improve the quality, productivity, efficiency and work environment. One of the most used methods during 1980s is "Quality Circles". Eight to ten employees come together, and meet regularly. They discuss quality problems, try to find solutions, investigate, and finally they achieve realistic results belonging to their qualitative findings.

*Self-Managed Teams* are formed of only employees. They do not have manager. They are responsible for a complete work process or segment that helps to conclude finally a product or service for an internal or external customer. Xerox, General Motors, Hewlett-Packard are a few of many companies that have performed self-managed work teams.

*Cross-Functional Teams* are composed of employees from same hierarchical level but belonging to different work areas in the organization. They get together to complete specific tasks. Cross-functional teams have been built by many companies for many years. All the major automobile manufacturers, Toyota, Chrysler, Nissan, General Motors, Ford, Honda, and BMW, use cross-functional teams to manage complex projects.

Cross-functional teams are also effective to exchange information, to develop new opinions, to solve the problems and to execute complex tasks. Creativity and diversity is mostly seen in cross-functional teams, because members have different area of specialization. Therefore, these teams can not be easily managed. This difficulty could be easily returned to an advantage with diversity. The diversity that exists in a team can help to find unique or creative results.

Johnson and Johnson's (1994) team classification is based on where the teams are used; work area, sports, and learning situations. They define *work team* as a set of people in interaction which is structured to maximize members' proficiency and success, and to cooperate and integrate members' effort with other members. *A sports team* is a set of people in interaction which is structured to improve members' athletic performance and to cooperate and integrate members' effort with other members. *A learning team* is a set of people in interaction which is structured from same hierarchical level of people to improve their knowledge and skills and to cooperate and integrate members' effort with other members.

Katzenbach and Smith (1993) classify three types of teams:

- Teams that run things,
- Teams that recommend things,
- Teams that make or do things.

On the other hand, Hackman's (1987) classification can be summarized according to the differentiation of degree of autonomy and control of the organization (as cited in Thompson, 2004):

*Manager-Led Teams*, most traditional type of team, are managed by the manager as a team leader. Other members of team are responsible for only their assigned work. The manager is responsible for controlling, managing performance processes, selecting members, controlling relations between team and company and overseeing design. Some examples of manager-led work teams are; automobile assembly teams, surgery teams, sports teams, and military teams.

*Self-Managing Teams* (Self-Regulating), increasingly common in companies, are managed by a manager as a team leader. Leader determines purpose of the team. Members are free about using any of the methods to achieve their purpose. Some examples are; executive search committees and managerial task forces. According to Stewart and Manz (1995); self-managing teams improve productivity, quality, savings, and employee morale, as well as contribute to reductions in absenteeism and turnover. (as cited in Thompson, 2004) The disadvantage is that leader of team has less influence about process and products for achieving goal. As an advantage, self-managing teams are time-consuming.

*Self-Directing Teams (Self-Designing),* assign their goal, methods, and processes themselves. Management is responsible for only the team's organizational condition. Self-directing teams are time-consuming. Occurrence of conflicts is high. Building of this kind of teams can be costly. Some disadvantages are; difficulties on monitoring their progress, marginalization of the team, and lack of team legitimacy.

*Self-Governing Teams* and boards of directors are responsible for performing a task, using their own methods, designing the group, and designing the organizational conditions.

A further classification made by Mason et al. (1996) is multidisciplinary teams, interdisciplinary teams, and interdisciplinary learning teams. Types of teamwork across the structural and process dimensions are compared in Table 2.

Table 2. Comparison of types of teams. (Mason et al., 1996, p.1)

| Characteristics of Teams | Multidisciplinary Teams | Interdisciplinary Teams | Interdisciplinary Learning Teams |
|---|---|---|---|
| **Focus** | Providing quality care<br><br>Achieving Care Outcomes | Providing quality care<br><br>Achieving Care Outcomes<br><br>May Attend to Process | Providing Quality Care Plus Continuous Improvement<br><br>Achieving Care Outcomes plus Team Learning |
| **Attitude toward change** | Accepts change | Accepts change | Stimulates and Embraces Change |
| **Attitude toward diversity** | Recognizes diversity | Respects diversity | Capitalizes on Diversity |
| **Roles** | Fixed | Fixed but collaborate | Flexible and Synergistic |
| **Presumptions about Leadership** | Physician leadership assumed | Is assigned or may emerge according to the situation | Emerges According to the Situation or Need |
| **Attitude toward patients and family** | Consulted on plan of care | Variable Range of Involvement in Plan | Partners in Designing a Plan of Care |

Lastly, Quality Council of Indiana (2005) classifies teams according to types of teams that are used by industries throughout the world. This classification can be summarized as;

*Quality Circles*: Circle is a group of people in production area which come together to work on improving the quality and lowering manufacturing costs.

*Quality Teams*: Quality teams are made up of by management but directed by members. Efforts of the team members are same with quality circles.

*Self Directed Teams*: Self directed teams select their team leader themselves to interface with other teams and manage team activities. Self directed teams are able to achieve their goals in a specified time. They have a wide liberty to do everything for achieving their goals.

*Natural Work Team Organization*: Natural work team leadership is usually given to the area supervisor. Team members come from the supervisor's work force. Members from outside (from specialist companies) can be included to team as an active member or a contributing guest.

*Cellular Teams*: Cellular teams are a bit different than natural work teams. Team is named "Cellular team" because the work cell arrangement in which a number of employees either fabricate or assemble parts. These teams can be managed by a supervisor or may be self directed.

*Six Sigma Teams*: Six sigma is a proven disciplined approach for improving measurable results for any organization. The structure and functional roles of Six Sigma Teams closely follow the description of project and ad hoc teams.

*Improvement Teams*: Members' of improvement teams are selected from different departments to solve the problem, or to improve the production. Problem is given from management and team should work on until they solve it.

*Project Teams / Task Forces / Ad Hoc Teams*: Members' of project teams are selected according to their experiences and directed by management to search into specific areas such as the modernization of a piece of equipment or solution to a customer complaint.

*Cross Functional Teams*: Cross functional teams are made up of individuals belonging to different departments or working in different work areas. Members should be knowledgeable about processes, policies, operations of their own specialization or functional area.

Table 3. Synopsis of team types, structures and applications (Quality Council of Indiana, 2005, p.5)

| **Team Type** | **Structure** | **Best Applications** |
|---|---|---|
| Improvement Teams | May be 8 to 10 members from a single department. | Can work on quality or productivity issues. A process improvement team can consist of multi-department membership and focus on process flow and product issues. |
| Quality Teams | May be 8 to 10 members from a single department. | May initially work on quality topics or overall department performance. Can evolve into self-directed teams. |
| Project Teams | Can have broad or specific member selection. May consist of all or part management. | Works on specific projects such as the installation of a conveyor system. Can also focus on material related items like an improved inventory control system. Usually disbands upon the completion of a project. |
| Six Sigma Teams | Generally 8 to 12 members with Black Belt or Master Black Belt support. | Works on specific processes or customer based projects of importance. Usually disbands upon project completion. |
| Cross Functional Teams | 8 to 12 members from different areas, departments, or disciplines | Members are carefully selected. Knowledgeable people are required. Very similar to project teams. Tends to deal more with policies, practices and operations. |
| Self Directed Teams | 6 to 15 members. Generally a natural work area team. May need area staff support. | Requires considerable training and exposure. Can be given objectives or develop their own. Some companies select people with cooperative skills to help with success. |

### 2.1.5 Characteristics of Effective Teams

Effective teams are needed for delivering high quality products and services to customers. In the related literature, there are several studies on team effectiveness.

Johnson and Johnson (1994) state that productivity of teams is not only an integration of team members' technical knowledge and task abilities;

> To be productive, teams must ensure that members perceive strong positive interdependence, interact in ways that promote each other's success and well-being, be individually accountable, employ their small-team skills, and process how effectively the team has been working (p.517).

According to Reid (1998), the common characteristics of high performing teams can be explained as follows;

- There's a common purpose / goal,
- Relationships are based on trust and respect between the team members,
- Task and process is balanced,
- Firstly everything is planned and then all the processes work according to the plan,
- Team members all participate problem-solving and decision making processes,
- Every member is different than the other; respecting and understanding each other is a purpose,
- Synergism and interdependence are valued,
- Team goals are always emphasized and supported,
- Individual performance that supports the team is rewarded,
- Effective communication exists between team members,
- Instead of debates, effective dialogues are done to solve group conflicts,
- Vary levels and intensity of work,

- There is a balance between work and home of the members,
- The way they work as a team critiqued, regularly and consistently,
- Continuous improvement is practiced.

According to Wheelan (1999); there are *ten key areas* that members of an effective-productive team should pay attention:

- Goals,
- Roles,
- Interdependence,
- Leadership,
- Communication and Feedback,
- Discussion, Decision Making, and Planning,
- Implementation and Evaluation,
- Norms and Individual Differences,
- Structure,
- Cooperation and Conflict Management (p.39).

According to Robbins and De Cenzo (1998), following points are important characteristics of an effective team:

- Having a clear understanding of their goals,
- Having competent members with relevant technical skills and abilities,
- Exhibiting high mutual trust in the character and integrity of their members,
- Being unified in their commitment to team goals,
- Having good communication systems,
- Possessing effective negotiating skills,
- Having effective leadership,
- Having both internally and externally supportive environments (p.339).

Above characteristics are summarized in Figure 2.


Figure 2. Characteristics of high-performing work teams (Robbins, De Cenzo, 1998, p.339)

Differently, according to Europe Japan Centre (2000), it is useful to divide into two categories of criteria which successful teams must have in place: preconditions and characteristics (p.39).

*Preconditions* are supplied by those who are outside the team, for example, those who built the team or those whom reports. Successful teams clearly know their purpose, role and importance, affecting the organization's strategic intent. Another important factor of *preconditions* is empowerment. They designate their own destiny themselves. Teams must be supported by the company or by the person to whom they give report. Successful teams also translate their purposes into measurable objectives. Every member knows, understands and accepts these objectives.

As the other category, c*haracteristics,* describe that teams should have to achieve success;

> To help teams understand their roles and accelerate their development, it helps if they have a knowledge of how teams work

> and the training to teach them about how to get better at being a team (Europe Japan Centre, 2000, p.50).

In successful teams, interpersonal skills of team members are necessary for having respect of each other's views, and being open to each other's opinions. Unproductive conflicts do not appear. Participation among members is very important factor in successful teams. People share their views, opinions, time and energy. Decision making is also an important factor of *characteristics*. Decisions are reached before proper evaluation, analyzing, and with gathering true information. New ideas, new technologies, better ways to do something are always searched by the team members for improving creativity. One gives an idea, the other puts on it and so on. Managing the external environment is necessary for successful teams. Team members interact with people who are outside the team. These could be other members of the organization. They can get information from them and share information with them.

### 2.1.6 Advantages of Teams

Recently, teamwork is very prevalent in companies. Its advantages are recognized year by year. Improving productivity, quality, and finding solutions easily for problems are some of the advantages of teamwork. It's common in the literature that the advantages of teamwork are given as the characteristics of it.

According to Mears (1994), teams improve skills, communication, participation, and effectiveness. Improving skills causes more talent and expertise, and promotes technical competence. Improvement of communication effects mutual respect, vertical and lateral, cross departmental lines, and more ideas

According to Robbins and Finley (1995), the advantages of teams can be summarized as follows;

*Teams increase productivity*: Team members can see the problems and solutions better than management, because they are closer to the action and also closer to the customer. Consequently, teams find effective solutions to improve productivity.

*Teams improve communication*: As team members are stakeholders of their own success, they communicate each other to share information and to delegate work.

*Teams do work that ordinary groups can't do*: A team is better than an individual or than a crew working in same discipline; because when they face up with a multifunctional task, people coming from different disciplines put their knowledge together and achieve whole.

*Teams make better use of resources*: Teams use the most important resource: "brain". Members use their brains as Just-In-Time idea. Every idea is considered and nothing wasted.

*Teams are more creative and more efficient at solving problems*: Teams are better because they are motivated, closer to the customer, and they combine multiple perspectives. As a result, they know more in depth than organization's hierarchical structure. So, they are more creative and efficient.

*Teams mean higher-quality decisions*: Good knowledge brings good leadership. Knowledge is shared to bring good ideas. Accordingly, leadership is shared to find higher quality decisions.

*Teams mean better quality goods and services*: Quality circles which is an early expression of the idea as mentioned in the previous sections, help to develop new ideas and energies of people to improve quality. In this sense, knowledge is also improved in the ambient of teams and it is used for continuous improvement.

*Teams mean improved processes*: Before processes, functions occur. Teams see all the possibilities that could appear before functions contribute to a process. Accordingly processes are improved better in a team.

*Teams differentiate while they integrate*: Teams generally want to downsize but work more effectively. But sometimes downsizing brings fragmentation in the organization. Teams allow companies to mix people together who have different kind of knowledge, without any fragmentation appearing.

### 2.1.7 Unsuccessful Teams

When companies are in a problematic position, they often act to form a team. However, collecting people to form a team is not always a solution. If it isn't planned deeply, it can cause additional problems. In the best circumstances, teamwork is advantageous. In the contrary, teamwork can lead to confusion, delay, and poor decision making. (Thompson, 2004)

In some companies, teams are not always working effectively. Some problems occur by means of team structure. Robbins and Finley's (1995) matrix (in Table 4) answers the questions of "Why teams don't work?" and "How to make it right".

Table 4. Why teams don't work (Robbins and Finley, 1995, p.14, 2p)

| PROBLEM | SYMPTOM | SOLUTION |
|---|---|---|
| Mismatched Needs | People with private agendas working at cross-purposes | Get hidden agendas on the table by asking what people want, personally, from teaming |
| Confused Goals, Cluttered Objectives | People don't know what they're supposed to do, or it makes no sense | Clarify the reason the team exists; define its purpose and expected outcomes |
| Unresolved Roles | Team members are uncertain what their job is | Inform team members what is expected of them |
| Bad Decision Making | Teams may be making the right decisions, but the wrong way | Choose a decision making approach appropriate to each decision |
| Bad Policies, Stupid Procedures | Team is at the mercy of an employee handbook from hell | Throw away the book and start making sense |

Table 4 (continued)

| | | |
|---|---|---|
| Personality Conflicts | Team members do not get along | Learn what team members expect and want from one another, what they prefer, how they differ, start valuing and using differences |
| Bad Leadership | Leadership is tentative, inconsistent, or stupid | The leader must learn to serve the team and keep its vision alive or leave leadership to someone else |
| Bleary Vision | Leadership has foisted a bill of goods on the team | Get a better vision or go away |
| Anti-Team Culture | The organization is not really committed to the idea of teams | Team for the right reasons or don't team at all; never force people onto a team |
| Insufficient Feedback and Information | Performance is not being measured; team members are groping in the dark | Create system of free flow of useful information to and from all team members |
| Conceived Reward Systems | People are being rewarded for the wrong things | Design rewards that make teams feel safe doing their job; reward teaming as well as individual behaviors |
| Lack of Team Trust | The team is not a team because members are unable to commit It | Stop being untrustworthy, or disband or reform the team |
| Unwillingness to Change | The team knows what to do but will not do it | Find out what the blockage is; use dynamite or vaseline to clear it |
| The Wrong Tools | The team has been sent to do battle with a slingshot | Equip the team with the right tools for its tasks, or allow freedom to be creative |

## 2.2 Product Development Teams

By the new millennium, companies confront an increasingly competitive environment and increasing pressure to perform new product developments. This new era seeks companies to provide newer, more exciting, innovative, and cost-effective products than ever before (Bean and Radford, 2000). In today's market, importance of product's quality, reliability, and durability is increasing day by day. Besides, other factors like cost and lead time affect competitiveness in the market (Monplaisir and Singh, 2002). Product development is ‘knowledge intensive work’ for successful new products by linking activities, such as research and development, marketing, product conceptualization, manufacturing system design, operations and supplier chain management. Integration of these activities is needed for a team oriented environment and shared decision-making for successful product development (Hong et al., 2005). By the collective efforts of individuals in new product development teams (hereafter, NPD teams), majority of successful innovations are developed (Akgun et al., 2006). Pinto (2002) defines new product development teams as organizational workgroups where different personal characteristics and organizational backgrounds of individuals come together for collaborative working to create, design, develop, and market a new product (as cited in Akgun et al., 2006). Trott (2002) says, NPD is not only a work of a single department in an organization. The process of NPD is a complicated and difficult to manage, hence a variety of different departments and functions comes together. Therefore, companies trend to form a group of people working as a team to develop new ideas, products, and projects for a final product which are adapted for sale.

> Product development teams are a way to re-organize personnel involved in product development to facilitate informal communication, sharing requirements, constraints and ideas early in the product development cycle. The result will be the parallel design of product and process and the early consideration of the constraints and factors that impact the successful development of competitive products (Crow 1996, p.1).

Bucciarelli (2002) declares that the participants are a collection of individuals whom purpose is ‘production for profit’. In this sense, there is a common goal, that is to say, they design ‘qualified’ products which will contribute to their and their firm’s existence. Participants are also in a competition with one another. Each participant works in different section. They have different responsibilities. Bucciarelli (2002) says; “The creations, findings, claims and proposals of one individual will conflict with those of another" (p.220). Members of a team work for a common goal but in contrary, their conflict of interests lead them to a competition.

### 2.2.1 Members of Product Development Teams

Product development projects may incorporate different functional departments within a company; they should be represented throughout the development effort since this representation ensures a higher degree of success for new products and addresses any potential development problems that may occur in the process.

Namely, product development process is a result of multidisciplinary effort that usually includes participants from: engineering, design, technical, marketing, sales, support, production, process development, quality, and finance departments. Participants contribute their expertise and knowledge to a balanced approach to making decisions (Rainey, 2005).

Benhabib (2003) declares that the product development team -from beginning to the end- must have the knowledge about quality, cost, insurance, and so on. As a different perspective, an example of a structure of product development team is shown in the Figure 3.

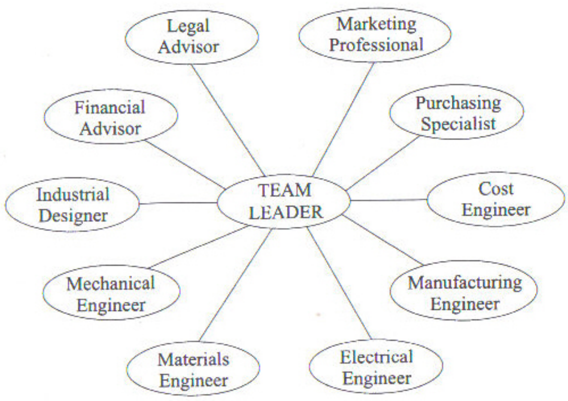



Figure 3. Example of structure of product development team (Benhabib Beno, 2003, p.40)

According to Cagan and Vogel (2002), when engineers work with engineers, or designers work with designers; as their knowledge and skills are same, they speak same languages. But when different disciplines come together, their approach to a problem is different when compared. The overlap of engineering, design and marketing disciplines (Figure 4) may be difficult because of conflicts. When engineers and designers work together; for example, “they often find themselves frustrated, feeling like the other party could care less for their concerns.” (Cagan and Vogel, 2002, p.140). As a result; this kind of feelings can affect design process. Also some conflicts may occur.

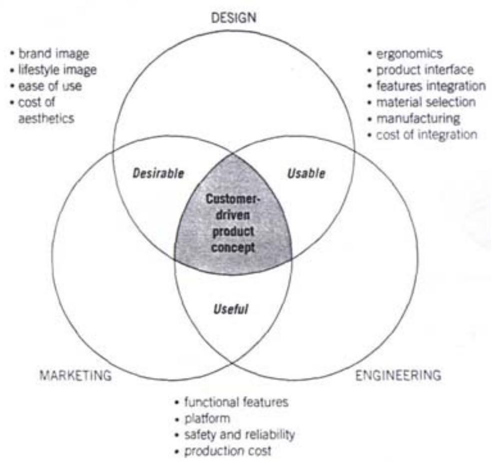



Figure 4. Overlap of disciplines leads to value (Cagan and Vogel, 2002, p.141)

Recently, different approaches are occurred with the idea of design integration. Such as collaborative engineering, simultaneous engineering, concurrent engineering, and integrated product and process design (Monplaisir and Singh, 2002; Ettlie and Stoll, 1990).

One of the most appointed area is collaborative engineering, which can be defined as “the cooperative exchange of resources –such as information and ideas- among a team of colleagues focused on an engineering-intensive project and generally having some overall common and creative purpose" (Mills,1998 as cited in Monplaisir and Singh, 2002).

Another one is concurrent engineering, which means that there is a strong connection between the participants of product development process, such that they can fulfill superior than their work at the same time (Fleischer and Liker, 1997). Koufteros et al. (2005) explain concurrent engineering as "the early involvement of a cross functional team in a process to plan product design, process design, and manufacturing activities simultaneously" (p.4).

Concurrent Engineering is occurred to cause the developers to attend the product life cycle from the beginning to the end and it is a "systematic approach to the integrated, concurrent design of products and their related processes" (Winner et al., 1988 as cited in Mora et al., 2000, p.204).

### 2.2.2 Stages of Product Development

To launch qualified products faster to the market, "staged product development" is an effective process (Rosenau and Moran, 1993, p.45). Every company customizes the stages according to customer needs and its own culture.

Rosenau and Moran (1993) give some examples of staged product development approaches of well-known companies. For example, Kodak's approach is as follows;

- Customer mission/vision
- Technical demonstration
- Technical/operational feasibility
- Capability demonstration
- Product/process design
- Acceptance and production (Wheelwright and Clark, 1992 as cited in Rosenau and Moran, 1993)

Similarly, Xerox' staged product development approach is as below;

- Preconcept
- Concept
- Design
- Demonstration
- Production
- Launch
- Maintenance (Johnson R., 1992 as cited in Rosenau and Moran, 1993)

These examples could be reproducible according to the companies. Rosenau and Moran (1993) state that "in many staged processes, specific criteria are clearly designated as prerequisite for the end of stages" (p.48). The list below summarizes the required end-of-stage deliverables to proceed to the following phase.

| <u>Product Phase</u> | <u>Deliverables</u> |
|---|---|
| Concept Phase | Define customer requirements |
| | Complete economic and technical feasibility analysis |
| | Identify critical success factors |
| | Develop phased product plan |
| Development Phase | Confirm business viability |
| | Select technology |
| | Develop functional team plans |
| | Initial financial projections |
| Design Phase | Benchmark product concept |
| | Test product functionality |
| | Demonstrate manufacturability |
| | Beta test prototype product |
| Manufacture/launch phase | Verify customer acceptance |
| | Confirm field readiness |
| | Ramp up production process |

Transfer to current product

(Rosenau and Moran, 1993)

### 2.2.3 The Role of Engineers in Product Development Process

Bean and Radford (2000) state multidisciplinary skills that are needed in product development process. Engineering takes place in “technical inputs”. Generally most manufactured products need engineering input. If this role isn’t qualified technically, then the project can not achieve its goal. Some companies that are developing products ineffectively, try to fill the role of engineers with people working in operating departments. A company must choose the people that are most creative, most capable, and most effective to achieve the goals. Engineers are qualified technically for analyzing and selecting the most advantageous materials and methods for producing an effective product.

By considering the phases listed in the previous section, the activities in manufacturing phase seem necessary for effective product development process. Activities are important inputs for cost effectiveness and reliability of both the product and manufacturing itself. This process needs a high performance team to achieve its goals. For this reason, knowledgeable engineers are needed to perform manufacturing phase (Wilson et al., 1996).

An engineer has knowledge about the theory of machinery and know-how of the manufacturing. “Engineering is an art to apply the science and technology, to increase the quality of our life, and to propel the society moving forward” (Zhang 2002, p.1). Engineers are supported about financial and managerial issues to introduce the product to sales department for customer satisfaction (Newell et al., 1999). Consequently, engineers are a bond between basic science and general public.

Accreditation Board for Engineering and Technology (ABET) defines engineering as “the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind" (as cited in Holmes, 2000, p.4).

Sandström and Toivanen (2002) denote design engineering as a product realization process, which all manufacturing issues are analyzed in. Engineers investigate cost, manufacturability and quality of the product for an effective decision. Consequently; they need to know the objectives of the company and ideas of the managers about their decisions. Their feedback is important for them.

Engineers must work closely to designers. The aim is preventing potential problems that could occur during the process. These potential problems can affect the final assembly. If these problems are prevented at the beginning, the design may need to be modified. Black (1996) says; "Generally, the earlier such modifications are identified, the better" (p.6).

The primary function of an engineer is to analyze the designs when designer finishes the drawings and layouts of a part or product. Designers and engineers share their knowledge in this analyzing session. Namely, creator explains the logic and the concept of the product, engineer explains if there is any complication in manufacturing of the design. This communication helps to solute some problems before manufacturing all the party (Ettlie and Stoll, 1990).

Koenig (1987) divides the field of manufacturing engineering into four areas; advanced manufacturing engineering; process control; methods, planning and work measurements; and maintenance. Advanced manufacturing engineering is the most related area with product design (as cited in Ettlie and Stoll, 1990). Koenig outlines advanced manufacturing engineering as; area planning, capacity analysis, capability evaluations, new technology evaluations and needs, producibility engineering, computer-aided manufacturing development, investment project management, and long-range planning and forecasts.

### 2.2.4 The Role of Industrial Designers in Product Development Process

The Industrial Designers Society of America (IDSA) defines industrial design as “the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer” (as cited in Benhabib, 2003, p.42). Crawford and Benedetto (2003) state, industrial designers are trained to learn how to design products that “function mechanically, that are durable, that are easy and safe to use, that can be made from easily available materials and that look appealing” (p.278). They try to find solutions continuously for arising problems. They give importance for how things work and look. Industrial designers have unique set of skills and abilities. In this sense, they play an important role in product development process.

Perks et al. (2005) summarize the evolution of the role of design in product development;

| | |
|---|---|
| 19th Century | : *Design is as Business Oriented*, |
| 1920s to 1950s | : *Design is as Specialized*, |
| 1960s to 1970s | : *Design is as Profession*, |
| 1980s | : *Design is as Brand*, |
| 1990s | : *Design is as Subprocess of New Product Development*, |
| Early 2000 | : *Design is as Product Development Process Leader*. |

According to Perks et al. (2005), specific objectives of the role of design are as follows;

- To articulate the scope and nature of actions that designers are undertaking in the new product development process;
- To identify and explore the skills associated with such actions and uncover how such skills are developed;

- To unravel the key contextual factors influencing and explaining these dynamics;
- To ascertain managerial implications from these findings (p.114)

Rainey (2005) expresses that designers collaborate with participants from manufacturing to design manufacturable products. Compatible product development team is critical for a robust product design. According to Wilson et al. (1996), an overall grouping of the subjects that designer should focus on at product design phase can be summarized as;

*Product characteristics:* features, performance, product cost target, quality and reliability targets, aesthetics, ergonomics, size, weight, and modularization.

*Product life:* the product's life span, lives for replaceable parts and modules, warranty period, and storage or shelf life.

*Customer use:* installation procedures, documentation, maintenance, and disposal.

*Product development considerations:* development time (time risks), use environment, materials used (hazards), standards and safety, testing, company constraints (resources), and patents and legal ("local content").

*Manufacturing and product delivery considerations:* process selection, production volumes, product packaging, and product shipment.

*Market definition and plan:* customer identification, competitive assessment, market window (price, place, and promotion), market share and size (p.129)

Wilson et al. (1996) also summarize the goals for product design and evaluation phase;

- Develop a complete Product Design Specification (PDS), translating the Final Product Definition into technical Specifications;
- Design, build, and test the product and subsystems by a controlled iteration process, thus developing a robust product by removing and preventing failure modes;

- Execute a comprehensive evaluation program, thereby verifying the designed product's value and fitness for manufacture and customer use;
- Plan and manage the Product Design and Evaluation phase activities so that the company's product development is faster than that of competing products while still delivering a robust, high value product;
- Confirm the target estimates of product's life cycle costs that support the successful business plan while solving any exceptional cost problems through appropriate actions; and
- Gain higher management support and financial commitment for product release to manufacturing by passing the Product Release Review (p.120)

As a proof of the importance of design, there are several ways in which design excellence can help companies achieve a broad spectrum of new product goals. Crawford and Benedetto (2003) summarize contributions of design to the new products process with a figure;

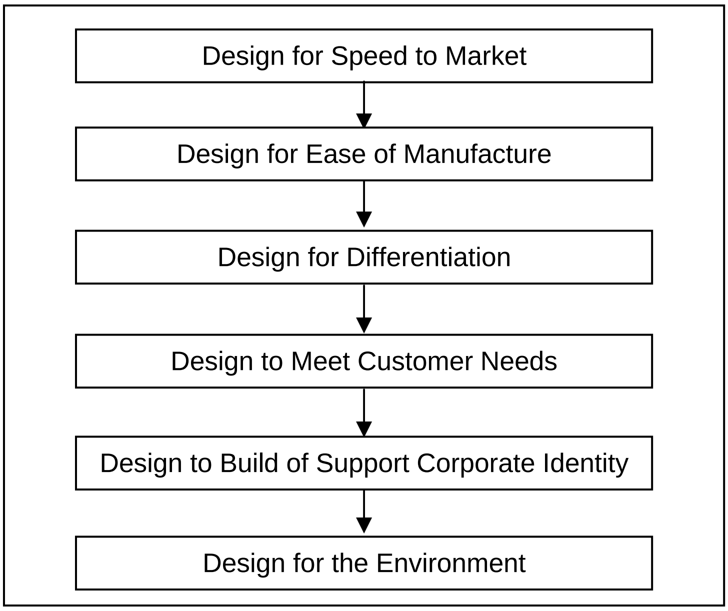



Figure 5. Contributions of design to the new products process (Crawford and Benedetto, 2003, p.279)

Differently, Rainey (2005) signifies integrated product design methodologies as ‘design for quality’, ‘design for reliability’, ‘design for manufacture and assembly’. Furthermore, Lindbeck (1995) examines some specific areas of the product-user relationship; ‘design for serviceability’, ‘design for security’, ‘design for vandalism prevention’, ‘design for safety’, ‘design for usability’, ‘design for the physically disadvantaged’. Black (1996) considers these approaches as “a number of external influences that are likely to sway the engineering decisions taken when introducing a new product” (p.220): ‘aesthetics’, ‘ergonomics’, ‘quantity’, ‘safety’, ‘strength, fatigue’, ‘corrosion’, ‘environment’, ‘conflict, compromise’.

As Wilson et al. (1996) state, the success of the product is related to design phase of product development process, because it is the stage that “robust products with high customer value” are created (p.117). A creative and detailed effort is needed for this design phase. Everything should be thought, and tested. Prototype of the product should be made as a representative of the final manufactured product. If a defective design is occurred, unpleasant surprises could appear when the product is on customer’s hands. These unexpected product failures while in manufacturing phase -or in the hands of the customer- exactly harm the company. Moreover, these failures can put companies out of business (Wilson et al., 1996). Eversheim et al. (2000) state “the disturbances occurring at production stage must be either prevented or compensated” (p.345). For an accurate product design; the information flow between product design phase and process planning should be identified. Product designers have to give first drafts to process planners (engineers) for assessing feasibility. If any problem is observed; it is easy to change the drafts. But in the future, it is much more difficult and also expensive to modify (Eversheim et al., 2000)

### 2.2.5 Perceptual Gaps between Engineers and Designers

In the literature, there are several studies on the differences between engineers and industrial designers. For example, Cagan and Vogel (2002) examine engineers and designers that how disparate disciplines they really have. They prepared a qualitative study with three different types of colanders. One of them is a stainless steel colander (a), the other one is a two-piece plastic molded colander (that won an award in 1995) (b), and the last one is a cheap, one shot injected molded colander (c). In this study, participants are; three studio designers, three from marketing, five engineers, and two suppliers (who happened to be trained as engineers). They asked to each participant: “If you owned a company, which colander would you prefer to sell and why?”. As the results show, decision process of engineers and designers are different than each other. Designers give importance for shape and aesthetics; engineers give importance for cost and complexity. These differences are called “perceptual gaps” according to Cagan and Vogel (2002). Perceptual Gaps are “the differences in perspectives that team members have that stem from discipline-specific thinking and prevent teams from developing an integrated interests-based conflict resolution process” (Cagan and Vogel, 2002, p.144). These gaps affect cooperation and collaboration strategies negatively. Perceptual gaps model is shown in Figure 6.

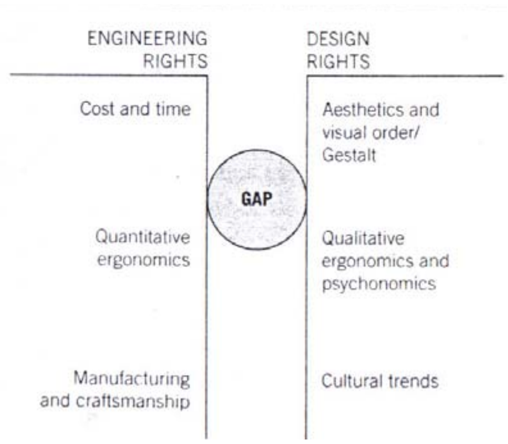



Figure 6. Perceptual gaps model (Cagan and Vogel, 2002, p.144)

Engineers are trained to do calculations with math and to use significant methods like statistics to reach a significant result. They want to conclude everything to a reasonable result. Their dictionary contains similar words like; right or wrong, black or white, and so on. They want to find what is “right” or what is “wrong”. They recognize “what can be done” or “what can’t be done”. Firstly they give importance to *functionality*. Form comes after functionality. Their aims are improving performance, quality and manufacturing with lower costs.

On the other hand, designers are trained about for finding solutions for “what should be”, not “what is”. They are visual thinkers. Their quality conception belongs to aesthetics and emotional impact. They have knowledge about manufacturing but they push the limits easily in the cause of designing better formed products. Designers are “more comfortable with uncertainty” (Cagan and Vogel, 2002, p.145).

Perception differences between designers and engineers are important and advantageous for the design process. These differences bring creative, affordable, and manufacturable goods on time. But sometimes these differences can cause some conflicts if each member does not respect the other.

### 2.2.6 Factors Affecting Product Development Team Success

Studies in the literature subject that, in some companies, teams work more effectively and more productively. The basic factor of the effectiveness of a team is ‘performance of team members.’ Behaviors of team members affect team success directly. Team dynamics are a mix of inter-related variables collectively determining how a team functions. This basic forces and variables assist in complementing the interaction within a team.

Frankenberger and Schaub (1998) centralize design process surrounded by four general influences in Figure 7.

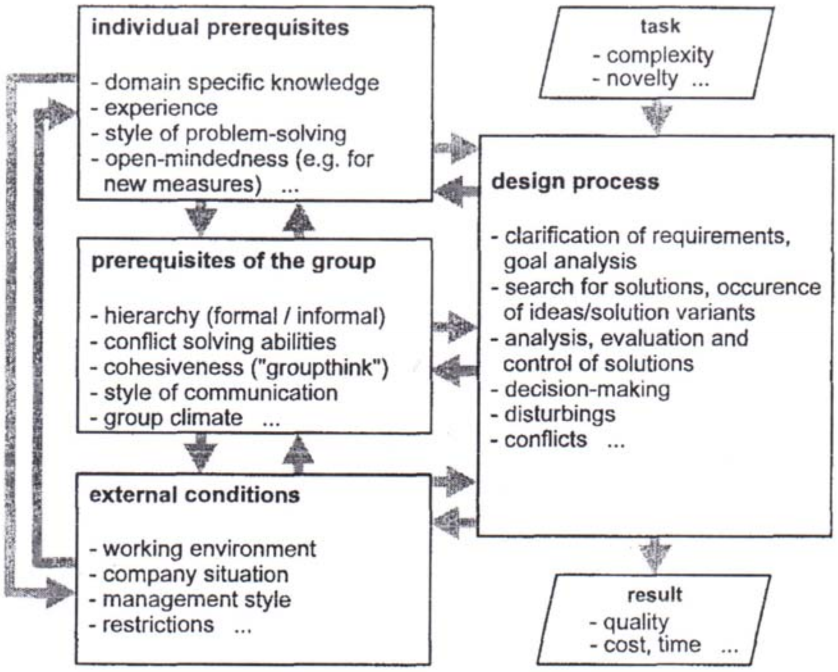



Figure 7. Influencing factors on the design process and the result (Frankenberger and Schaub, 1998, p.141)

To come to the point, as the literature review study demonstrates, teamwork has such basic variables which the research part of this study is based on; cooperation, collaboration, coordination, communication, goal consciousness, collaborative problem solving and decision making, leadership, and team learning.

2.2.6.1 Cooperation

It is apparent that cooperation is an important factor for the effectiveness of a team. Team members, especially engineers and industrial designers, cooperate for developing well-designed, high qualified, low costly and manufacturable goods.

Prasad (1996) summarizes steps of team cooperation;

- To gather data, materials, and behavior information.
- To understand the concurrent engineering goals.

- To specify weighting factors for the life-cycle aspects and goals.
- To make decisions and act on them.

Zhuge (2003) emphasizes that cooperation is difficult to manage with people who come from different backgrounds, but it is possible to cross the barrier with high-level cognitive cooperation mechanism. Designers and engineers come from different backgrounds. They are trained for different goals. But if they come together with a consciousness of high degree knowledge, skill and experience sharing; maximum cooperation will be configured. And actually, they achieve team's goals.

According to Zhuge (2003), cooperation between members determines efficiency and effectiveness of the team. Members cooperate at three levels, from low to high. At *Work cooperation* level, members work according to the team's workflow definition. At *Information Sharing* level, members share information according to a predefined sharing model. At *Cognitive Cooperation* level, members cooperate actually by sharing their knowledge, experiences, and skills to solve the problems.

Wheelan (1999) summarize characteristics of cooperative groups;

- More effective communication
- Friendlier group atmosphere
- Stronger individual desire to work on group tasks
- Stronger feelings of commitment to the group
- Greater division of labor
- Greater coordination of effort
- Greater productivity
- Increased trust and the development of lasting agreements
- Increased ability to resolve conflicts

Tjosvold (1985) finds the following results after a series of research about the cooperative interaction;

(1) If team members discuss their contrary thoughts and views cooperatively then all attitudes and approaches can become apparent.

(2) Team members are open-minded for listening other's thoughts. They want to understand their beliefs and their rights by asking questions.

(3) Team members work together for a common goal.

(4) Some of the team members influence the others. They are open to be influenced. By the way some controversy positions return to be advantageous for the team.

(5) Each member respects to the other. Opposition and snubbing does not happen because controversies are solved by the people who influence each other without trying to "dominate or force each other".

(6) Decisions are given by integrating member's thoughts and ideas. (as cited in Guzzo et al., 1995)

Monplaisir and Singh (2002) explore benefit of 'meetings' for effective cooperation. Designers and engineers can come together to show prototypes, documents, drawings and so on and to find new solutions and new ideas. They can use problem solving techniques, like brainstorming to find new concepts.

Zhuge (2003) states that a team's cooperation degree can be measured according to the factors below;

- The match between the special knowledge required for solving the problem and the team's overall special knowledge;
- The degree of similarity between team members' knowledge;
- The average creativity and co-operative spirit of the team members.

2.2.6.2 Collaboration

Collaboration is an important factor that affects teamwork success since knowledge integration and conflict resolving is procured in the short run (Rainey, 2005). Prasad (1996) define collaboration as, to seek out the unplanned and unpredictable activities among team members. Crow (2002a) states that “the basis for bringing together the knowledge, experience and skills of multiple team members to contribute to the development of a new product more effectively than individual team members performing their narrow tasks in support of product development” (p.1).

Fleischer and Liker (1997) state collaboration is an important issue for the conflicts occurring between engineers and industrial designers. If they share their ideas and information, and work collaboratively for achieving an innovative solution, every team member wins. On the other hand, as Rainey (2005) denotes, collaboration helps for providing design requirements and downstream implications.

According to Crow (2002a), requirements of effective collaboration are;

- Early involvement and the availability of resources to effectively collaborate
- A culture that encourages teamwork, cooperation and collaboration
- Effective teamwork and team member cooperation
- Defined team member responsibilities based on collaboration
- A defined product development process based on early sharing of information and collaboration
- Collocation or virtual collocation
- Collaboration technology (p.1)

Lang et al. (2002) summarize factors for successful collaboration;

- Cognitive synchronization/reconciliation,
- Developing shared meaning,

- Developing shared memories,
- Negotiation,
- Communication of data, knowledge, information,
- Planning of activities, tasks, methodologies,
- Management of tasks.

Crow (2002a) stresses; an effective collaboration also requires an effective teamwork. Designers and engineers must understand and trust each other. In product development process, many times conflicts may occur, but "decision-making must be based on a collaborative approach." It is shown in the following model;

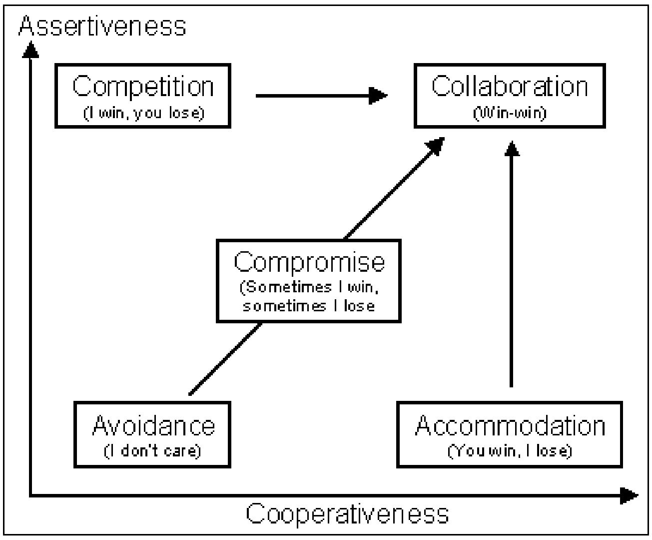



Figure 8. Model of collaborative approach (Crow, 2002, p.1)

Crow (2002a) also defines some tools and technologies to provide information between team members;

- Email exchange of drawings, models and project information (asynchronous)
- Teleconferencing and videoconferencing (synchronous)
- Web-hosted meetings (synchronous)

- Project hosting tools to create one pool of all released project documentation, with email alerts for updates (asynchronous)
- Drawing viewing sites (intranet and web-based) with view and mark-up capabilities (asynchronous)
- CAD collaboration sessions (synchronous)
- Workflow and groupware software (asynchronous)
- Product data management, product information management, collaborative product commerce (generally asynchronous)

As observed in the literature review, some researchers list these tools and technologies as "communication" techniques. Theses will be summarized in the section about "Communication".

2.2.6.3 Coordination

A team needs coordination for managing skills, efforts, actions, and members for effectiveness. Members can be successful in their working area individually, but unless they coordinate their facilities together, they can not achieve their collective goals. Prasad (1996) define coordination as, to manage interdependencies among activities of the product development teams. Another definition states coordination as "a continuing need" which is "best provided by time-based activity-on-arrow diagrams" (Rosenau and Moran, 1993, p.144). Thompson's (2004) definition on coordination is as "combined synchronization of the strategies of all members" (p.35).

Guzzo et al. (1995) summarize definition, subskills and alternative labels of "coordination" which is favored by various researchers:

> Coordination is the process by which team resources, activities, and responses are organized to ensure that tasks are integrated, synchronized, and completed within established temporal constraints (Guzzo et al. 1995, p.345).

Subskills and alternative labels of coordination are as follows;

- Task organization
  - Coordination of task sequence
  - Integration
- Task interaction
  - Technical coordination
  - Response coordination
- Timing and activity pacing

According to Kelley (1962), as the team gets larger; problems increase and coordination of the team becomes more difficult (as cited in Thompson, 2004).

According to Boujut and Laureillard (2002), the difference between cooperation and coordination is concerned with the aim of the members of team. Cooperation requires a common goal. This goal must be designated with all members, not separately. Figure 9 shows the radical difference between coordination and cooperation.

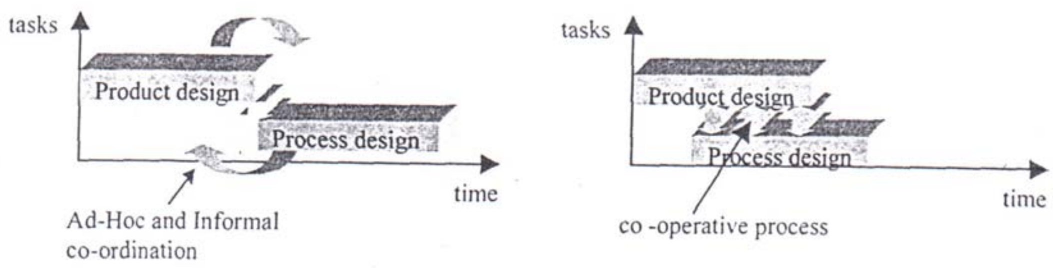



Figure 9. Co-ordination versus co-operation (Boujut and Laureillard, 2002, p.501)

Reid et al. (2000) denote that engineers work interdependent in a team. For an integrated design solution, positively ‘co-ordination’ is needed.

2.2.6.4 Communication

Communication affects the performance of product development team. Poor communication between designer and engineer affects the product directly (Rosenau and Moran, 1993). The term *communication* refers to the "exchange of information between sender and receiver" (Guzzo et al. 1995, p.25). Similarly, Prasad (1996) define communication as, to exchange information among team members. Namely, engineers and designers in a product development team communicate for exchange of information. According to Monplaisir and Singh (2002), communication is necessary for participation, control and conflict resolution. Fleischer and Liker (1997) call communication technology as "coordination mechanism".

> Communication is the process by which information is clearly and accurately exchanged between two or more team members in the prescribed manner and with proper terminology; the ability to clarify or acknowledge the receipt of information (Guzzo et al. 1995, p.345).

Subskills and alternative labels of communication are listed below;

- Information exchange
    - Closed-loop communication
    - Information sharing
    - Procedural talk
    - Volunteering/requesting information
- Consulting with others
    - Effective influence
    - Open exchange of relevant interpretations
    - Evaluative interchange

People come together to exchange information for an effective product development. Designers and engineers work together to bring their efforts, knowledge and expertise. Namely, communication is necessary for achieving company's goals. According to Harvey and Koubek (2000), members must pay attention about the “words” they are using to express their own ideas to another member.

According to Ettlie and Stoll (1990), for an effective communication;

- People who have more skills and have more experience must work on together for the projects. In the long run, they will know their views, contributions of each other completely. Few people can be added later.
- Importance of proximity
- Joint actions (plans, decisions, meetings, and so on.)
- Using all benefits of technology for interaction; e-mails, messages, networks, multi-access databases, progressive updating of data, and so on.
- Pushing for physical demonstration of progress, not progress reports.
- Package work so that the most of the communication is within the work group.

Monplaisir and Singh (2002) define ways of communication as; electronic mail, desktop conferencing, and video conferencing. E-mail is used to reduce cost of coordination and to speed up information sharing. Video conferencing is used for the companies who communicate with in different places. Desktop conferencing is used for instant communications. To sum up, these types of technological communication groupware are advantageous for both improving communication skills and also reducing communication costs. Moreover, Stewart and et al. (1999) emphasize ‘*communication networks*’ for an effective communication. Similarly, Perry and Sanderson (1998) denote benefits of increased use of computer and communication technologies for an effective communication. As a whole summary, Fleischer and Liker (1997) display communication technologies in a table. (Table 5)

Table 5. Communication technologies from low to high richness (Fleischer and Liker, 1997, p.175)

| Communication Technologies | Description | Richness | Best for |
|---|---|---|---|
| Formal written messages (paper or electronic mail) | One-way communication of words only, without intonation, body language, or immediate feedback | Low | ← One-way, low frequency |
| Shared databases | Rated higher than other formal written messages because of the quantity of information and because changes to the database are rapidly accessible to all users. | Medium | ← → Two-way asynchronous, low frequency |
| Computer conferences | Provides delayed feedback; not as strong as face-to-face meetings since body language and verbal and visual cues are removed. | Medium | ← → Two-way asynchronous, low frequency |
| Personal written messages (paper or electronic mail) | Two-way communication without audio cues, but personalized and directed to the individual receiver; can be direct feedback to a message from the receiver. | Medium | ← → Two-way asynchronous, high frequency |
| Voice mail | Can be personalized and provide audio cues; asynchronous so feedback from the receiver is not immediate. | Medium | ← → Two-way asynchronous, high frequency |
| Telephone | Provides audio cues and immediate feedback; not as strong as face-to-face as body language and visual cues are removed. | High | ←→ Two-way synchronous, high frequency |
| Video conferences | Allows reading some body language and visual cues; less complete and vivid than face-to-face meetings. | High | ←→ Two-way synchronous, low frequency |
| Face-to-face meetings (coming together from distant places) | Immediate feedback allows understanding to be checked, interpretations corrected and ideas to build on each other. Allows reading of body language and visual cues. | Very High | ←→ Two-way synchronous, low frequency |
| Face-to-face meetings (collocation) | Same as above, but can meet with greater frequency. | Very High | ←→ Two-way synchronous, high frequency |

According to Rosenau and Moran (1993), several steps of improving communications skills are;

- Planning what is to be communicated beforehand rather than trying to decide while communicating. As it is sometimes stated, “Put brain in gear before opening mouth.”

- Using face-to-face meetings in which you can observe the other person's "body language." Allow enough time at an appropriate time of the day.
- Deciding which sequence and combination of telephone discussion, face-to-face meeting, and memo will be most effective.
- Being consistent and following through with actions appropriate to your message.
- Using simple language. (p.151)

Another way of improving communication between designers and engineers is *proximity*. According to Rosenau and Moran (1993), these members should be located closely for an increased communication. If people see each other more often, then they will start to know each other more quickly. They can speak more effectively, and fluent. This frequent contact will tend the members to be more uniform. So, proximity will effect communication directly and clear understanding of both sides.

Another issue for an effective communication is *feedback*. When one of the sides denotes something to the other; he should wait for restating. This can help to overcome a listener's closed mind. Another technique could be; after declaration of an idea, organizing a meeting to discuss it (Rosenau and Moran, 1993). Also Wheelan (1999) harmonizes communication and feedback. Feedback improves effectiveness and productivity. Teams get feedback both internally and externally to be more successful. Accordingly, communication is needed for getting effective feedback.

Crow (2002b) denotes that; there are three important factors for effective communication; "willingness to talk and share information and effectively presenting point of view", "active listening", and "understanding". Similarly, Fleischer and Liker (1997) specify two aspects; "expressing yourself" and "listening". Designers and engineers must express their ideas clearly to the other one for preventing misunderstandings. Also listening is important as expressing ideas. If they listen carefully, they can understand each other easily. At this point, feedback comes into prominence. If both side expresses their ideas clearly and listens their ideas carefully; their feedback will be more effective.

Varvel et al. (2004) define effecting factors for '*mature communication*' as;

- Articulate ideas clearly and concisely,
- Give compelling reasons for their ideas,
- Listen without interrupting,
- Clarify what others have said, and
- Provide constructive feedback (higher level of understanding (p.143)

2.2.6.5 Goal Consciousness

Individual goals bring decreased performance (Guzzo et al., 1995). In the literature, it is seen as a matter of fact; groups have individual goals, but teams have common goals. Engineers and designers come together as a team for a common goal. As mentioned before, they share their skills, knowledge, and experiences to achieve their goal. In this point, importance of goal consciousness arises. All team members must know and work for team's goal (Ettlie and Stoll, 1990).

Same words can mean different things to different people. Accordingly, all team members must understand team goals clearly by communicating with each other.

Members of high performance teams think the goal is "reasonable" and "attainable". Namely, members feel that the goal is necessary to work and necessary for the organization's avail (Wheelan, 1999).

According to Bean and Radford (2000); team goals must be focused on "the result" not "the means". Goal statements can be either internal measures or external measures. The important thing is that a goal shouldn't be overlap with another goal. Goal overlapping can bring some conflicts, too. Goal statements must be time-specific and measurable as well.

> Clearly defined goals are quantifiable and commonly agreed upon statements that define the actions to be taken by the team. The attainment of specific goals helps teams maintain their focus (Varvel et al., 2004, p.143).

2.2.6.6 Collaborative Problem Solving and Decision Making

Huitt (1997) states that problem solving is a process in which people compass and resolve a gap between the present condition and the desired target, with the path to the goal blocked by known or unknown obstacles. Team members generate optimal solutions to problems when they come together. Each member examines the problem in a different view; consequently collaborative problem solving can provide a "valuable social input" and it is an important factor for achieving team objectives (Stewart and et al., 1999).

Problems must be analyzed, detailed and solved with a high speed. Solutions must be investigated and eliminated by the time. If members discuss the problems adequately on time; problem-solving ability, creativity, and effectiveness of team increases (Johnson and Johnson, 1994).

Guzzo et al. (1995) define decision making as;

> The ability to gather and integrate information, use sound judgment, identify alternatives, select the best solution, and evaluate the consequences (in team context, emphasizes skill in pooling information and resources in support of a response choice) (p.346).

Collaborative problem solving and decision making have been studied by a number of researchers. Shaw (1986) gives the steps of the procedure (as cited in Wheelan, 1999);

- Recognizing the problem
- Diagnosing the problem
- Making the decision
- Accepting an implementing the decision

(p.58)

Wheelan (1999) states that other researchers outline the process, similar to Shaw's;

- An orientation phase
- A discussion phase
- A decision phase
- An implementation phase

(p.59)

In orientation phase, problem is defined and strategies are outlined clearly. In discussion phase, alternative solutions are found. In decision phase, an agreeable decision is given by the members. And lastly, in implementation phase, the decision is put into practice (Wheelan, 1999). After decision phase, team members must plan to implement the best alternative solution and monitor implementation of that plan. And finally, they must verify if the problem has been resolved.

McNamara (1997) explains more detailed procedure for problem solving and decision making. He believes that, after defining problem, team members must look at potential causes for the problem. Then, members must identify alternative solutions. After all, decision phase comes through.

#### 2.2.6.7 Leadership

In the literature, there are several studies on leadership in companies. It is indisputable that leadership is important for companies. Some people believe that leadership is necessary for achieving success. But some are ambivalent about leadership's effects on teamwork (Thompson, 2004).

Thompson (2004) defines this position as “Team paradox”. Teams often need a leader to define goals, coordinate actions and motivate members. But team paradox comes into prominence when leaders’ existence is very sensible. If they show their existence a lot, teamwork can be affected negatively.

Guzzo et al. (1995) summarize definition of “leadership/team management” which is determined by various researchers:

> Leadership is the ability to direct and coordinate the activities of other team members, assess team performance, assign tasks, motivate team members, plan and organize, and establish a positive atmosphere (Guzzo et al., 1995, p.345).

A leader’s first mission is to find out the defaults of the team, and solve them as quick as possible. Leader performs or gets it performed (Day et al., 2004). An effective team leader creates a climate that encourages “mutual performance monitoring, supportive behavior, and adaptability.” Marks et al. (2001) emphasize that a leader is thought to diffuse leadership skills and abilities to the team that are used in influencing core processes, such as transition, action and interpersonal processes. Team leaders work for achieving team purpose and goals, building commitment and self-confidence, discovering the team’s collective skills and approach, crossing barriers, and creating opportunities (Katzenbach and Smith, 1993).

According to Stewart et al. (1999), there are three kinds of teams; *externally managed teams*, *self-managing teams*, *self-leading teams*. Externally managed teams have strong leadership, that leaders give all decisions. Self-managing teams are some more free and leadership is not as strong as externally managed teams. Leader’s mission is to generate discipline, to manage time, to test the quality, and to manage materials and repairs. Self-leading teams have high autonomy than the others. They select their leader themselves. They decide what to do, when to do and how to do.

According to Wheelan (1999), the role of the leader changes at different stages. At stage 1, leader is expected to be “directive”; at stage 2, there are some challenges between members and leader’s authority and control. But as same as stage 1; leaders direct the team and they listen members’ ideas. At stage 3, members accept many of the roles of leader. At stage 4, member act like a leader. They achieve master degree.

According to Guzzo et al. (1995), leaders play an important role on team performance. They plan, model and set teamwork for a successful teamwork process. Guzzo et al. (1995) denote that, team performance is affected from team leadership. Team leader must know all capabilities of the members to coordinate and employ them in their specialized area to be more effective. They also explain that, team leader’s important mission is to provide feedback and recommendations for improvement.

Mears (1994) summarizes leader responsibilities as;

- Making pre-meeting preparations,
- Finalizing and distributing the agenda,
- Helping establish, and then abiding by, team ground rules,
- Keeping facilitator (in this case, the instructor) informed of progress,
- Moving the group to a quality outcome by:
- Shared planning
- Shared appraisal
- Free, voluntary expression
- Acceptance of members as valuable individuals

Katzenbach and Smith (1993) summarize six necessary things for successful team leadership:

- Keep the purpose, goals, and approach relevant and meaningful,
- Build commitment and confidence,
- Strengthen the mix and level of skills
- Manage relationships with outsiders, including removing obstacles,
- Create opportunities for others,

▪ Do real work.

According to Bean and Radford (2000), a good project leader has the following characteristics;

▪ An interest in the project and the product,
▪ Good interpersonal skills,
▪ Competence in at least one technical aspect of the project,
▪ Good strategic sense,
▪ Good decision-making skills,
▪ Good experience in project management

Clark and Wheelwright (1995) give an example about leaders and leadership. Product development is a difficult stage. If it is liken as a mountain climbing; it is known that, the path is not easy, mountain is steep and steps should be taken carefully. Equipments must be professionalized. Leader's role is important that, they should know the right mountain for climbing, they should plan, and build climbing skills, and lead the team to overcome all obstacles they come through.

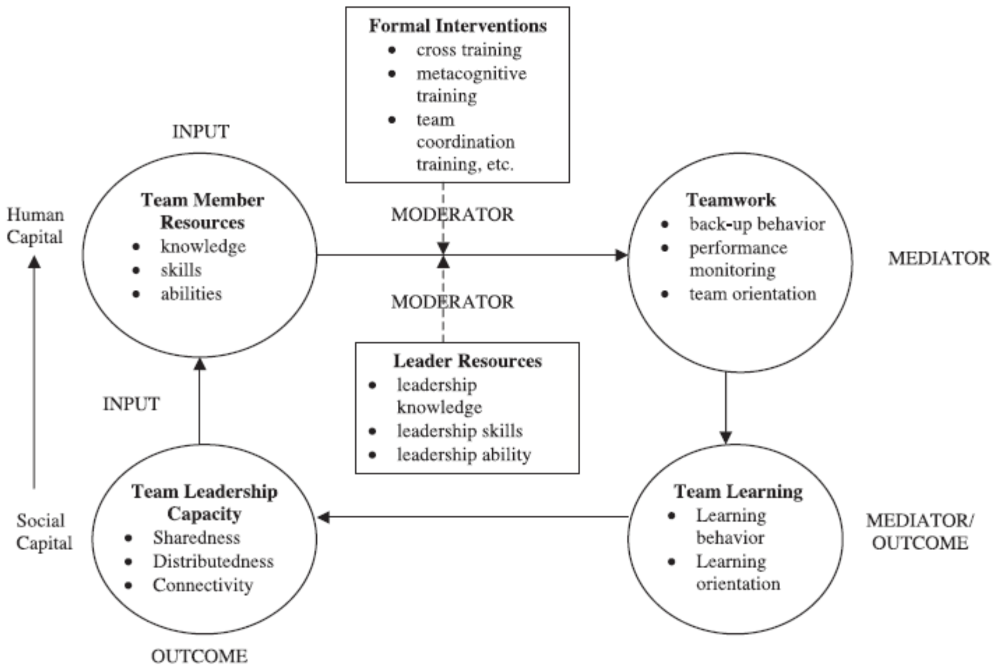



Figure 10. Team leadership cycle (Day et al., 2004, p.862)

Day et al. (2004) prepare team leadership cycle to show the *intersections of leaders and aspects of teamwork.* (Figure 10)

In the related literature, there is no study about the team leader's profession. It seems it isn't important whether the team leader is an engineer or an industrial designer. It seems the most important thing is, team leader's leading capacity, characteristics, and skills.

2.2.6.8 Team Learning

It is obvious that team learning depends on the members' of team. It belongs to their ability of sharing knowledge, skills and abilities with other members (Day et al. 2004).

Collin (2002) studies on learning at work especially focusing on product designers and development engineers. He made an interview with 18 people. As a result of this analysis a great variety of themes on learning at work is found. After phenomenographic analysis, Collin's (2002) six different categories of description can be summarized as;

1. *Learning through doing the job itself.* Learning is compassed while experiencing in real everyday problem solving and decision making situations. Learning by doing can also be performed by observing, monitoring and modeling other members.

2. *Learning through co-operating and interacting with colleagues.* This category is executed by performing meetings, having discussions, listening each other, asking advice, and listening their experiences.

3. *Learning through evaluating work experiences,*
    - This category is divided into three parts;

- Learning through one's own work experience: This is a common way of learning. Experiences help to move correctly in similar situations.
- Learning from mistakes: "Good" mistakes are effective sources for learning the rights.
- Learning through the accumulation of experiences and competencies: Repeated problem solving situations, and competencies in different cases help for learning more about the work.

4. *Learning through taking over something new.* This category is about approaching new problems with new creative ideas, finding new information, technology and so on. There are six different categories to apply this category;

    - Learning through finding out: Designing needs a continuous search to improve knowledge, and new technologies. Experience is not necessary in this stage.
    - Eureka-experiences from the subconscious: Conscious actions are not always the best actions for solving problems. In some conditions, people can solve problems subconsciously.
    - Innovating/discovering/thinking: Innovation is not a part of "finding out" activity.
    - Applying and connecting theoretical and practical knowledge (knowledge as a tool): Theoretical knowledge must be integrated with experiential.
    - Experimenting: This subcategory is connected with "learning from mistakes". Designers reported; "the only way of getting forward is through incidental experimentation, which from time to time may lead to success" (Collin, 2002, p.145)

- Creating: Creativity is an important variable in product development. New solutions can occur with creative design.

5. *Learning through formal education.* Education is a substructure of learning at work. Results of Collin's study show that without any technical education no one can learn anything new at work. Learning ability and ways of learning is comprehended in formal education.

6. *Learning through extra-work contexts.* Learning also continues outside work and school.

    - Interest in technical matters: Interest to all kinds of technical tools improves technical way of thinking.
    - Benchmarking: Contacts, meetings, and discussions with people working in the same field can be helpful for learning new ideas, new tools and so on.
    - Trade fairs, friends, clients and customers as a source of learning: People can learn different solutions from friends, clients and customers.

Consequently, Collin (2002) summarized importance of learning at work for achieving team success as in the above. Engineers and industrial designers can learn while working, cooperating, and interacting. Their experiences, knowledge, and technical and practical information can be advantageous for each other.

In the next chapter; methodology of the research study will be presented. Teamwork effectiveness for successful product development in Turkey, focusing on the relationship between industrial designers and engineers, will be investigated. Some affecting factors will be criticized as a result of the study.

# CHAPTER 3

## METHODOLOGY

### 3.1 Overall Design of the Descriptive-Survey Study

After a broad literature review on the effectiveness of teamwork in companies and in product development processes, this chapter presents a descriptive-survey study conducted in order to corroborate the literature review findings by concentrating on the situation in Turkey about this topic.

Engineers and industrial designers, working together in product development teams of companies in Turkey, are favored as possibly the most informant people about the current situation of teamwork in Turkey. With this purpose, a questionnaire composed of both qualitative and quantitative items is prepared to get their opinions on the effectiveness of teamwork approach in product development processes, and on the situations in their companies related with the teamwork processes and their relations. Sending e-mails via Internet is chosen as the survey media since it is an easy and quick way of reaching various engineers and industrial designers at the same time. Accordingly, Turkish discussion platforms on the Internet that have mostly members from the areas of engineering and industrial design are searched. Finally, two leading discussion platforms which have members who are generally engineers and/or industrial designers are selected for sending the questionnaire of the survey study.

## 3.2 Research Questions

As mentioned in the initial pages of this thesis, the purpose of this study is to explore the effectiveness of teamwork for successful product development process by focusing on the relationship between the team members – especially engineers' and industrial designers' relation.

Belonging to this purpose, the main research question of this study is;

What are the factors influencing the effectiveness of teamwork on the success of product development processes carried out by teams especially having both engineers and industrial designers as members?

The study also serves for finding answers for following questions:

What are the aspects of teamwork influential on the product development processes?

By considering the teamwork aspects, how does the relationship between engineers and industrial designers affect the teamwork success in product development processes?

What does the term 'teamwork' refer to for the companies having product development teams in Turkey and what are the characteristics of those groups so-called 'product development teams'?

By considering the ones who are the members of the product development teams of the companies in Turkey, what are the engineers' and the industrial designers' opinions about teamwork approach, their roles and relations in teamwork processes, and the effects of teamwork aspects to their success?

### 3.3 Population and Sample

Population of this study includes engineers and industrial designers who are working in a product development team within a manufacturing company in Turkey.

An introductory e-mail (Appendix A) explaining the purpose of the study and seeking voluntary respondents has been sent to two discussion groups via Internet which directly related with the areas of engineering and industrial design;

- "TurkCADCAM: Turkey's New Product Design, Development, CAD/CAM/CAE, and production technologies portal", which has 6.132 members who are generally engineers and industrial designers.
- "ETMK Platform: Industrial Designers Society of Turkey Platform", which has 1.080 members who are generally industrial designers.

After the introductory e-mail is sent, fifty-eight (58) people asked for the questionnaire to fill in. To those voluntary respondents, another e-mail (Appendix B) is sent with the attached questionnaire.

Three of fifty-eight people returned by e-mails mentioning that they haven't read the introductory e-mail clearly, and when they read the questionnaire, they understood that their profile is not appropriate for filling the questionnaire. Twenty-nine people filled out the questionnaire. One of them is excluded since she is currently working in a foreign country. Consequently, sample of this study consists of twenty-eight respondents;

*Graduation profiles of the respondents who work as industrial designers;*

| | |
|---|---|
| Industrial Design | 12 |
| Technical Machine Drawing Construction | 1 |

| | |
|---|---|
| Design and Construction Teaching | 1 |

*Graduation profiles of the respondents who work at engineering position;*

| | |
|---|---|
| Mechanical Engineering | 10 |
| Industrial Engineering | 1 |
| Electrical and Electronic Engineering | 1 |
| Machinery of Technical Vocational School of Higher Education | 1 |
| Molding Teaching | 1 |

Totally, fourteen of respondents work at a position responsible for engineering issues and the remaining fourteen work at a position responsible for industrial design issues in various companies in Turkey.

## 3.4 Data Collection Instruments

A twelve-item questionnaire (Appendix C) which has four open-ended questions and eight Likert-scaled statements has been prepared. Likert-scaled statements have been prepared in order to get both qualitative and quantitative data. Respondents specify their level of agreement to the statements. If they have any comment about the statements, they have spaces below each statement to fill in. Qualitative data is important for this study to have the detailed opinions of respondents about the subject. Questionnaire starts with some warm-up questions which help to have the profile of the respondents by getting information about their profession, company, position, some identifiable questions about their product development teams, and so on.

Questions and statements of the questionnaire with their means are explained in detail in Chapter 4: Results.

### 3.5 Data Collection and Analysis Procedures

The first set of data is gathered from the warm-up questions. Distribution of team leader professions has figured according to respondents' answers. And average value of the population of team members has calculated.

The second set of data is gathered from first four open-ended questions. The data classified as respondents' positions. Two-columned table was prepared. The data was recorded under the columns, engineers and industrial designers, for each question. Similar answers summed up in the right column for gathering quantitative data. Hereby, all qualitative data are coded quantitatively. After all respondents' answers were recorded on the table, answers are sorted by descending according to quantitative results. Consequently, the data has lined up according to the two groups of respondents' answers. Some factors affecting teamwork effectiveness according to each member was gathered.

The third set of data is gathered from Likert-scaled statements on a scale from 1 to 5 ('1' is 'strongly disagree' and '5' is the opposite). Choices have been transferred into quantifiable data as;

| Choices | Values |
|---|---|
| Strongly agree | 5 |
| Agree | 4 |
| Neither agree nor disagree | 3 |
| Disagree | 2 |
| Strongly disagree | 1 |

As it is known, all quantitative data is based on qualitative judgment. In this sense, for each question, average value of data was found. And each data was compared with the average value of last question's (performance of the team) data.

## 3.6 Limitations of the study

In the questionnaire some qualitative and quantitative data are gathered. Limitation of qualitative data is; the quality of the data collection and the results are highly dependent on the skills of the researcher and on the rigor of the analysis. Because all of these methods are dependent on respondents and all results found by the researcher may influence the quantity and quality of information given by respondents.

Qualitative research does not gather quantitative data from a representative sample of the target population. Eventually, this type of research cannot be exposed to statistical analysis to estimate the opinions stated by respondents reflect the opinions of the population surveyed. The most important implication of this limitation is that researcher should refrain from concluding such actual prevalence of specific concerns, attitudes, or beliefs among the target population.

As this survey study is carried out with limited number of respondents whom are member of TurkCADCAM and ETMK Platforms, the results are only found for making the readers have an idea about the effectiveness of teamwork on the relationship between engineers and industrial designers. But these results may not reflect the specific concerns, attitudes or beliefs of whole population.

# CHAPTER 4

## RESULTS

### 4.1 Results of the Study Questionnaire

Results of the questionnaire are given in the order of the questions' aims, and reasons of why they are asked. Then the absolute answers to the questions will be presented in the Conclusion Chapter without much interpretation since the interpretations of the results of both literature review and survey studies are presented.

#### 4.1.1 Profiles of the Respondents' Teams

Data about the profiles of product development teams of the respondents and their members are gathered from warm-up questions. Warm-up questions are as follows;

- Name, surname of the respondent
- Educational background of the respondent
- Name of his/her company and its main field of activities
- Department and position of the respondent
- Specific name of the respondent's product development team
- Quantity of the members of product development team and their professions
- Profession of the team leader (if any)

There are twenty three different companies that respondents belong to and there are two respondents each, in five of these companies. When the main field of activities of companies is investigated, five of them are working for automotive industry, four of them are working for electrical industry, four of them are working for electronics industry and the rest are working for various industries such as steel construction, refining industry and so on. Companies of seven respondents denominate their product development team as ‘team’, companies of six respondents denominate their product development teams as ‘group’, companies of six respondents denominate their product development team as ‘department’, and the rest do not use any denomination about ‘collective’ working. Product development team members of these companies come from minimum two and maximum six different disciplines. Industrial designers are not employed in product development teams of five companies. Instead of industrial designers; mechanical engineers or technical machine drawing construction graduates or design and construction teaching graduates work as industrial designer in product development teams of companies.

A table is prepared that summarizes the profiles of the respondents and the profiles of their teams (Appendix D). Companies are classified according to their main field of activities.

#### 4.1.1.1 Population of the Respondents’ Teams

In the warm-up questions, population of the team members is asked to find an average value of the population of members in the product development teams in Turkey. One of the respondents has no comment for this question. One of the respondents answers this question as 80 people, and two of the remaining answer as 200 people. These three respondents express that, there are many teams in their company. Every team works on a different project. Probably, these quantities are the total number of the members of all teams. Consequently, four of twenty eight respondents are eliminated to find a correct average value of the population of members in the product development teams. The following figure (Figure 11) shows the respondents’ answers. The line shows the average value (X = 9,5833) of the total quantity of the population of members that work in the product development teams.

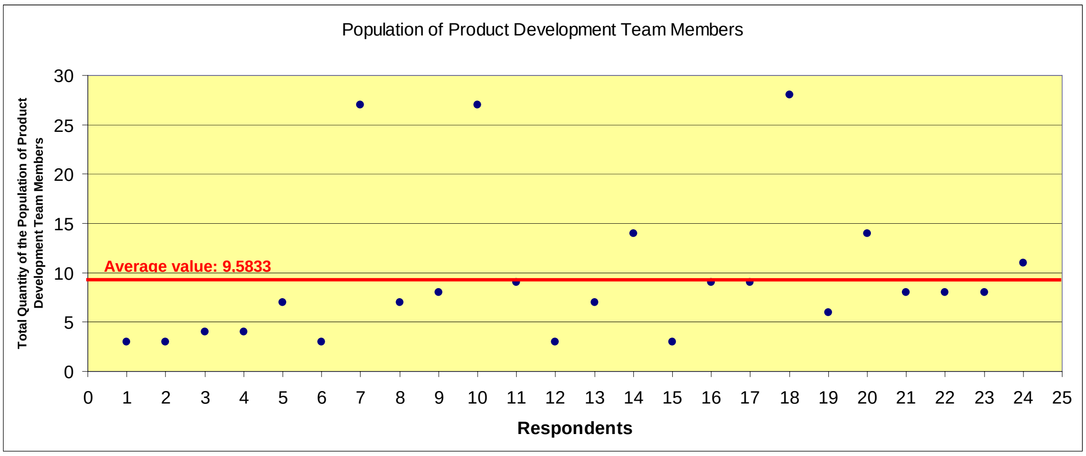



Figure 11. Population of product development team members

### 4.1.1.2 Profession of Team Leaders

In the questionnaire, profession of team leaders is asked for finding the percentages of the team leader's professions in Turkey within the limitation of the sample of this study. Results show that; sixty four percent (64%) of team leaders are engineers. Twelve of twenty-eight team leaders are mechanical engineers, four of them are electronics engineers, one is chemical engineer, and the other one is aeronautical engineer. Fourteen percent (14%) of team leaders are industrial designers. (Figure 12)

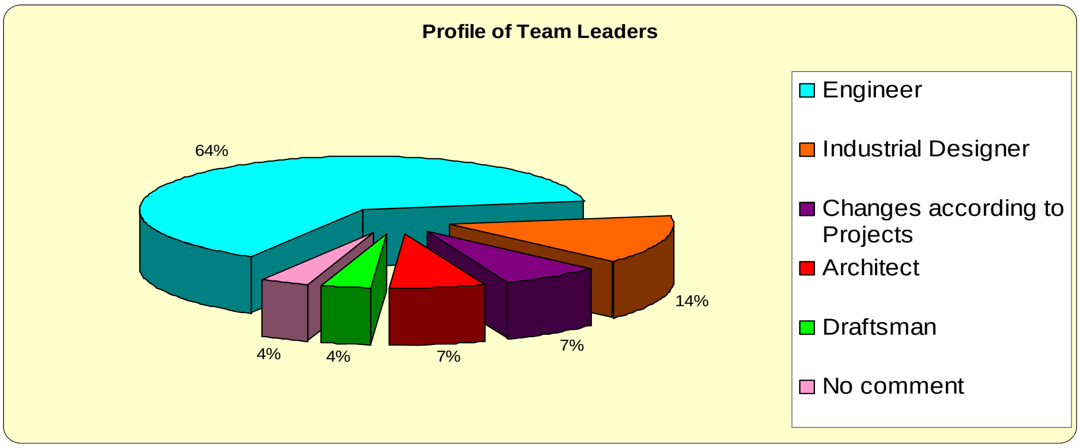



Figure 12. Profile of team leaders

### 4.1.2 Results of the Open-Ended Questions

Four open-ended questions are prepared to have qualitative data from respondents about;

- Listing the most important five factors effecting the success of a product development team in both positive and negative ways,
- Defining the main roles of industrial designers and engineers in product development teams,
- Describing the process of product development in their company,
- Describing the most important five factors effecting the engineer-industrial designer relationship within the product development process in both positive and negative ways, with their reasons.

In Question 1 and Question 4, the researcher also gathers the factors affecting team success negatively. The aim is to investigate negations for transferring the results into opposite. For example; being “unsystematic” is a negative affect; but as a result, being “systematic” can be recorded as a positive affect.

#### 4.1.2.1 Factors Affecting Product Development Team Success

The aim of this question is to have the opinions of respondents on the factors affecting product development team success positively and negatively.

<u>Positive Factors Affecting Product Development Team Success</u>

Respondents’ answers are classified according to their professions as mentioned in the Methodology Chapter. Italic words between the quotes are the respondent’s original expressions.

Results of the analysis of the engineers' answers are as follows;

- Nine engineers (64%) remark the importance of "*teamwork which has members understanding each other*" and "*cooperation*" for successful product development.
- Six engineers (43%) believe the importance of "*financial resources*".
- Five engineers (36%) express "*time limitation*". This expression is found in both positive and negative factors with its adverse. Namely; "Time limitation" effects team success negatively.
- Five engineers (36%) emphasize "*qualifications of team members*". Teams must be formed from multi-disciplinary members whom are essential for the related project.
- Four engineers (29%) specify the importance of "*knowledge*" and "*education*".
- Three engineers (21%) mark "*creativity*" and "*abilities*" of the team members.
- Three engineers (21%) state "*working environment*". They also complain about its negative affect on team performance.
- Three engineers (21%) believe in the importance of "*experience*". Experiences have to be shared for an effective product development.
- Two engineers (14%) denote "*market analysis*" to have information about competitors.
- Two engineers (14%) emphasize the importance of "*self edification*".
- Two engineers (14%) state "*self-sacrifice*" and "*ambition*" of the team members.
- Two engineers (14%) notice the positive effect of "leadership" on product development team success.
- Two engineers (14%) believe that "*customer relations*" must be good for successful product development.
- Two engineers (14%) emphasize "*process management*" to achieve success

Finally, other terms that are mentioned only once are as follows;

> "*technology, marketing strategy, usability of test area, design plan, organization chart, analytical thinking, periodical control and verifications, motivation, organizing meetings for sharing ideas and opinions, goal consciousness, system engineering, project management, resource management, collaborative problem solving and decision making, sharing knowledge and mutual learning, coordination, preparing prototypes, preventing problems before production stage, available software, and enough quantity of team members*"

According to industrial designers, the factors effecting product development team success are as follows;

- Seven industrial designers (50%) express the importance of "*sharing information*" and "*mutual learning*" which are the benefits of learning team.
- Six industrial designers (43%) notice "*resource management*". Planning and programming the needs is important for successful product development.
- Five industrial designers (36%) inform the importance of "*leadership*".
- Five industrial designers (36%) state the importance of "*organization chart*" and "*fairly shared activities*".
- Five industrial designers (36%) denote "*process management*". Every process must be clearly defined and understood.
- Five industrial designers (36%) notice the importance of "*teamwork*", "*cooperation*" and "*collaborative working ability*" for successful product development.
- Four industrial designers (29%) specify "*communication*" between the team members.
- Four industrial designers (29%) notice "*harmony*" of the team members.

- Two industrial designers (14%) mark "*creativity*" and "*abilities*" of the team members.
- Two industrial designers (14%) state "*working environment*". They also complain about its negative effect on team performance.
- Two industrial designers (14%) express "*time limitation*". This expression is found in both positive and negative factors with its adverse. Namely; "Time limitation" effects team success negatively.
- Two industrial designers (14%) state "*having detailed information about disciplines and job descriptions of all team members*".
- Two industrial designers (14%) emphasize "*openness for innovations and improvements*".
- Two industrial designers (14%) express "*speaking same language*" within all team members.
- Two industrial designers (14%) notice the importance of "*coordination*" for successful product development team.
- Two industrial designers (14%) believe that "*collaborative problem solving and decision making*" is necessary for successful product development.

Finally, other terms that are mentioned only once are as follows;

> "*experiences, synergy, visiting domestic and international fairs, sufficiency and abilities, giving importance for design, vision, clear goals, giving award for success, successful purchasing team, and self-sacrifice*"

When answers of both groups are analyzed, respondents' opinions are common on these subjects;

- ✓ Fourteen respondents (50%) remark the importance of "*teamwork*" and "*cooperation*" for successful product development.
- ✓ Eight respondents (29%) express the importance of "*sharing information*" and "*mutual learning*" which are the benefits of learning team.

- ✓ Seven respondents (25%) complain about "*time limitation*". If there is no time limitation, team members can work more effectively.
- ✓ Seven respondents (25%) express the importance and positive effect of "*leadership*" on product development team.
- ✓ Seven respondents (25%) denote the importance of "*process management*" for a systematic and planned product development team.
- ✓ Seven respondents (25%) express the importance of "*resource management*".
- ✓ Five respondents (18%) state the effect of "*working environment*" on product development team.

<u>Negative Factors Affecting Product Development Team Success</u>

Respondents' answers are classified according to their professions as in the previous section.

Results of the analysis of the engineers' answers are as follows;

- Eight engineers (58%) believe that "*incoordination*", "*being unsystematic*", and "*being unplanned*" are the important issues that effect product development team success negatively.
- Five engineers (36%) state "*unclear goals*" which have negative effect.
- Four engineers (29%) express the importance of "*costs*".
- Two engineers (14%) complain about "*limited resources*".
- Two engineers (14%) mention "*deficient market and feasibility analysis*".
- Two engineers (14%) notice "*deficient communication*" between the team members.
- Two engineers (14%) state "*difference of multi-disciplinary languages*".
- Two engineers (14%) complain about "*inability to make prototypes*".
- Two engineers (14%) denote "*deficient knowledge*".

- Two engineers (14%) complain about "*having no feedback from the other team members*".

Finally, other terms those are mentioned only once are as follows;

> "*globalization, environmental conditions, defining customer needs defectively, multitude of people working for design, hierarchy, having no innovation ability, unwillingness, individualism, sensibility, stress, being inexperienced, focusing on many subjects at the same time, disorganized shared activities, unsuccessful decision making process, and too many work load*"

Industrial designers' answers are as follows;

- Five industrial designers (36%) complain "*time limitation*". Product development teams are affected negatively from limitation of time.
- Five industrial designers (36%) state the importance of the "*working environment*".
- Four industrial designers (29%) notice "*competition between team members*", "*individual ambitions*", and "*individualism*".
- Four industrial designers (29%) complain about "*deficiency of motivation*".
- Four industrial designers (29%) complain about "*unutilized experiences*", "*deficiencies in sharing knowledge*", and "*deficiencies in technical information*".
- Three industrial designers (21%) state "*deficient communication*" between the team members.
- Three industrial designers (21%) complain that "*team members do not work with a team spirit*".
- Two industrial designers (14%) notice "*psychological problems*".
- Two industrial designers (14%) express negative effect of "*uncertainty of management*".
- Two industrial designers (14%) complain about "*too many work load*".

- Two industrial designers (14%) complain about "*missing organization chart and job descriptions*".

Finally, other terms those are mentioned only once are as follows;

> "*negative energy, incorrect decision of producing techniques, incorrect analysis, being unappreciative, being hidebound, low convincing ability of team members, and not having responsibility (self distrust)*".

When answers of both groups are analyzed, respondents' opinions are common on these subjects;

- ✓ Eight respondents (29%) complain about "*incoordination*", "*being unsystematic*", and "*being unplanned*".
- ✓ Five respondents (18%) complain about "*deficient communication*".
- ✓ Five respondents (18%) complain about "*unclear goals*".
- ✓ Five respondents (18%) complain about "*time limitation*".
- ✓ Five respondents (18%) complain about "*working environment*".

#### 4.1.2.2 Roles of Industrial Designers and Engineers

The aim of this question is having the opinions and descriptions of the roles of industrial designers and engineers from both groups. In the answers; both common and different expressions are used. The following table (Table 6) illustrates "the roles of the industrial designer in engineers' and industrial designers' points of view."

Results show that; engineers express the roles of the industrial designer mainly on these features;

- Giving importance to ergonomics,
- Designing visual appearance of the products,
- Giving importance to aesthetics,
- Designing for usability,
- Analyzing customer needs.

Industrial designers express their own roles mainly as;

- Giving importance to usability, visual appearance, harmony, and structuralism,
- Communicating with engineers to get feedback,
- Analyzing customer needs,
- Designing according to customer needs,
- Producing new ideas and new concepts,
- Analyzing problems in a wide perspective.

Table 6. The roles of the industrial designer in engineers' and industrial designers' points of view

| | | | | |
|---|---|---|---|---|
| ROLES OF INDUSTRIAL DESIGNER | Gives importance to ergonomic structure | 42,9 | Usability, visual appearance, harmony, structuralism | 28,6 |
| | Forms visual appearance of the product | 35,7 | Communicates with engineers to get feedback | 21,4 |
| | Gives importance to aesthetic | 28,6 | Analyzes customer needs | 21,4 |
| | Designs for usability | 28,6 | Designs according to customer needs | 21,4 |
| | Analyses customer needs | 21,4 | Produces new ideas and new concepts | 21,4 |
| | Uses the area effectively | 7,1 | Analyzes problems in a wide perspective | 21,4 |
| | Designs economical | 7,1 | Designs manufacturable and mouldable products with engineer-industrial designer cooperation | 14,3 |
| | Designs for manufacture | 7,1 | Gives importance to aesthetics and ergonomics | 14,3 |
| | An industrial designer who certainly knows product, is as free as possible on the product that has borders made by engineers | 7,1 | Deals with qualitative aspects | 7,1 |
| | Designs products that address target markets | 7,1 | Investigates new trends | 7,1 |
| | Gets feedback from production | 7,1 | Studies to get information about materials science | 7,1 |
| | Concept design | 7,1 | Studies to get information about moulding | 7,1 |
| | Creative | 7,1 | Increasing competition with innovations | 7,1 |
| | Designs with a wide perspective | 7,1 | Transfers designed products to mechanical designer for production stage | 7,1 |
| | Aware of technological innovations | 7,1 | Designs product development process | 7,1 |
| | Self innovator | 7,1 | Good manager | 7,1 |
| | Designs for assembly and serviceability | 7,1 | Not only styles, but also has knowledge about structure as much as engineers | 7,1 |
| | Designs package | 7,1 | Develops and designs idea, function, and form | 7,1 |
| | | | Concept design | 7,1 |
| | | | Form, type, material, color selection | 7,1 |
| | | | Elaboration | 7,1 |
| | | | Follows revisions | 7,1 |
| | | | Designs with endless imagination | 7,1 |

On the other hand, the roles of the engineer in engineers' and industrial designers' views are presented in Table 7.

Results show that, majority of engineers express their own roles as;

- Making technical analysis; some tests; strength, resistance, integration, and so on,
- Finding solutions for functionality, workability and practicability,
- Working for manufacturability.

Majority of industrial designers define the roles of the engineer as;

- Designing manufacturing processes,
- Finding solutions with the help of feedback from the designer,
- Working for manufacturability,
- Providing technical information.

Table 7. The roles of the engineer in engineers' and industrial designers' points of view

| | ANSWERS OF ENGINEERS | PERCENTAGE (%) | ANSWERS OF INDUSTRIAL DESIGNERS | PERCENTAGE (%) |
|---|---|---|---|---|
| ROLES OF ENGINEER | Making some tests; strength, resistance, integration, and so on. Generally, makes technical analysis | 64,3 | Designs manufacturing processes | 50,0 |
| | Works for functionality, workability and practicability | 35,7 | Finds solutions with the help of getting feedback from designer. | 42,9 |
| | Works for manufacturability | 35,7 | Works for manufacturability | 35,7 |
| | Producing with lower costs and appropriate processes in minimum time | 14,3 | Provides technical information | 21,4 |
| | Finds solutions with the help of getting feedback from designer. | 14,3 | Aware of technological innovations | 14,3 |
| | Works for producing product which serves its purpose | 14,3 | Produces the product which is designed by industrial designer | 14,3 |
| | Solves technical problems while working on the project | 7,1 | Deals with quantitative aspects | 7,1 |
| | Budget management | 7,1 | Responsible for mechanical-practicability | 7,1 |
| | Must have a good engineering education | 7,1 | Prepares product for manufacturing in series | 7,1 |
| | Must have design experience | 7,1 | Has signature authority | 7,1 |
| | Makes mechanical design | 7,1 | Produces new ideas and new concepts | 7,1 |
| | Comprehends customer needs | 7,1 | Finds solutions for probable problems that can rise while producing | 7,1 |
| | | | Finds probable problems with the help of prototypes | 7,1 |

### 4.1.2.3 Product Development Process in Companies

This open-ended question is asked to have an idea about the stages of product development processes in the respondents' companies. One respondent has no comment on this question, and another respondent states that 'there isn't any organized or systematic process working in their company'. According to him, this situation causes some conflicts between engineers and industrial designers in their company. The rest of the respondents answered this question in detail. As expected, there is no unique list of stages describing product development process shared by the respondents' companies. However, when looking at their common points, all respondents describe their product development process by below stages;

Concept Stage

- searching customer needs

Development Stage

- developing design plan
- searching new technologies

Design Stage

- designing the product
- prototyping
- testing functionality

Manufacture/launch Stage

- manufacturing in series

Each company has additional stages or steps performed in product development process. Some of them are as following;

- There are several feedbacks while these phases are in process.
- Customer acceptance plays role in different stages of product development processes.

#### 4.1.2.4 Factors Affecting the Engineer-Industrial Designer Relationship within the Product Development Process

The aim of this question is to have the opinions of respondents on the factors affecting the engineer and industrial designer relationship within the product development team success positively and negatively.

Positive Factors Affecting the Engineer-Industrial Designer Relationship

Respondents' answers are classified according to their profession as in the first question.

Engineers' answers with percentages are listed below.

- Nine engineers (64%) express the importance of "*cooperation*" between engineers and industrial designers.
- Seven engineers (50%) state "*sharing knowledge*" and "*mutual learning*". These definitions are related with "Learning team" as in the literature survey.
- Four engineers (29%) notice the importance of "*coordination*" within engineers and industrial designers for product development team success.
- Three engineers (21%) specify good "*communication*" between engineers and industrial designers. They also define communication to be "*productive*" and "*continued*".
- Three engineers (21%) believe the importance of leadership on the relation between engineers and industrial designers. A "*professional*" leader manages the relations and improves the performance of the team.
- Two engineers (14%) explain the necessity of "*getting feedback from both sides*". Feedback helps to achieve more effective results. Engineers and industrial designers have to get feedback from each other while they are working as a member of a team.

- Two engineers (14%) state "*collaborative process management*". Product development process has to work with collaboration of industrial designers and engineers.
- Two engineers (14%) notice the importance of "*working environment*". This expression is also stated in the first question's answers as an effective factor.
- Two engineers (14%) mark "*stabilization*", "*reality*", and "*belief of achieving goals*".
- Two engineers (14%) emphasize the importance of "*team harmony*".
- Two engineers (14%) stress on "*technical sufficiency*".
- Two engineers (14%) state the importance of "*friendliness*" and "*sociability*".

Finally, other terms that are mentioned only one time are as follows;

> "*speaking same technical language, preparing a wide database concerning product, self edification, materialistic and spiritual satisfaction, giving importance for perceived usability, sharing responsibilities, and collaborative decision making*".

Industrial designers state the positive factors affecting the engineer and industrial designer relationship within the product development team success as follows.

- Nine industrial designers (64%) believe in the importance of "*sharing knowledge and experiences*" and "*mutual learning*". Their suggestions are;
    - There should be network for sharing knowledge,
    - Databases should be easy and open for the usage of each member,
    - Engineer can be inspired by industrial designer's free and creative approach,
    - Industrial designer can learn about engineer's methodic and scientific approach.

- Six industrial designers (43%) notice that “*having clear job descriptions*” affects the relationship between engineers and industrial designers.
- Five industrial designers (36%) state the importance of “*communication*”. They also add comments about communication; “*listening to each other with respect*” and “*building positive social and professional relations with each other*”.
- Four industrial designers (29%) remark the importance of “*cooperation*” on the product development team success. “*Synthesis of industrial designer’s independent solutions and engineer’s productivity and material knowledge*” is stated as an expression of cooperation.
- Four industrial designers (29%) stress ~~on~~ the “*collaborative decision making*”.
- Three industrial designers (21%) express the importance of “*speaking same technical language*”.
- Three industrial designers (21%) believe in the effect of “*team harmony*”.
- Two industrial designers (14%) give importance on “*learning sufficiency of engineers and industrial designers*”.
- Two industrial designers (14%) mention “*process management*”. They express as, “*all processes occurring during product development must be determined*”.
- Two industrial designers (14%) believe in the importance of “*the attitude of manager*”. Namely; “*manager must stand on equal distance between engineers and industrial designers*”.

Finally, other terms that are mentioned only once are as follows;

“*building empathy, individual relations, design department must be independent from the other departments, leadership, being aware of technological innovations, integration and planning*”.

When answers of both groups are analyzed, respondents' opinions are common on these subjects:

- ✓ Sixteen respondents (57%) notice the importance of "*sharing knowledge and mutual learning*" (Learning team),
- ✓ Thirteen respondents (46%) believe in the necessity of "*cooperation*",
- ✓ Eight respondents (29%) remark "*communication*".

<u>Negative Factors Affecting the Engineer-Industrial Designer Relationship</u>

Respondents' answers are classified according to their profession as in the previous section.

Engineers' answers are listed below.

- Four engineers (29%) complain about "*jealousy*", "*obstinacy*", and "*individual competitions*".
- Three engineers (21%) complain about "*working independent from each other*". Engineers and industrial designers make decisions without asking the ideas of others. The product development team success is affected from "*independent working*".
- Three engineers (21%) state "*having no knowledge about capabilities of each other*".
- Two engineers (14%) notice "*conflicts in visual appeal and manufacturability*". One of the engineers mentions "*industrial designer's obstinacy on the subject that engineer does not approve its manufacturability*" causes conflicts.
- Two engineers (14%) specify "*misunderstanding customer needs*".
- Two engineers (14%) notice "*unclear goals*".
- Two engineers (14%) complain about "*working environment*".
- Two engineers (14%) complain about "*deficient communication*".

Finally, other terms that are mentioned only once are as follows;

> "*costs, hierarchy, having no innovation ability, unwillingness, incoordination, stress, time limitation, speaking different languages, deficient knowledge, thinking industrial design parameters as valueless* ".

Industrial designers answered the factors <u>negatively</u> affecting the engineer and industrial designer relationship within the product development team success as follows.

- Three industrial designers (21%) complain about "*conflicts on visual appeal and manufacturability*". One of the industrial designers mentions "*engineer's effort for changing the concept of the product because of manufacturability anxieties*". Another industrial designer mentions "*because of industrial designer's deficiency of information on materials and production, engineers work on the job again that industrial designer worked before*".
- Three industrial designers (21%) complain about "*conflicts on visual appeal and costs*".
- Two industrial designers (14%) complain about "*jealousy*", "*obstinacy*", and "*individual competitions*".
- Two industrial designers (14%) complain about "*the differences between two disciplines on design concept and practices*".
- Two industrial designers (14%) complain about "*unawareness of the importance of design*" effects the engineer and industrial designer relationship within the product development team success negatively.
- Two industrial designers (14%) believe in the negative effect of "*time limitation*". This expression is also stated in the first question's answers as an effective factor.

Finally, other terms that are mentioned only once are as follows;

> "*time limitation, industrial designers do not want to deal with technical details, engineer solves the problems independently*

*from industrial designer in prototype stage, changeable and short termed teams, competition of performance, standing away from decisions, difference between wages, conflicts, having no innovation ability* ".

When answers of both groups are analyzed, respondents' opinions are common on these subjects;

- ✓ 21% of respondents believe that "*jealousy*", "*obstinacy*", and "*individual competitions*" have negative effects.
- ✓ 17% of respondents complain about "*conflicts on visual appeal and manufacturability*".

4.1.3 Results of Likert-Scaled Statements about Factors Affecting the Engineer and Industrial Designer Relationship within the Product Development Team Success

Likert-scaled statements are prepared to have opinions of respondents' about their product development teams on the factors affecting team success which are searched in the literature. Statements are about effects of team leaders, goal consciousness, social communication, professional communication, continuing mutual learning (learning team), coordination and cooperative problem solving and decision making. Statements are prepared to gather a valuable data from respondent's level of agreements on these factors within the context of their product development teams. Average values of the answers given for each question are figured. (Figure 13)

$\overline{A}$ = Average value of level of agreements about "*the affect of the team leader is high."*

$$= (a_1 + a_2 + a_3 + \ldots\ldots + a_{27} + a_{28}) / 28 \qquad (1)$$

$\overline{B}$ = Average value of level of agreements about "*Each team member has a clear and common idea about goals/objectives*."

$$= (b_1 + b_2 + b_3 + \ldots\ldots + b_{27} + b_{28}) / 28 \qquad (2)$$

$\overline{C}$ = Average value of level of agreements about "*The social communication between engineers and industrial designers in our product development team is very good.*"

$$= (c_1 + c_2 + c_3 + \ldots\ldots + c_{27} + c_{28}) / 28 \quad (3)$$

$\overline{D}$ = Average value of level of agreements about "*The professional communication between engineers and industrial designers in our product development team is very good.*"

$$= (d_1 + d_2 + d_3 + \ldots\ldots + d_{27} + d_{28}) / 28 \quad (4)$$

$\overline{E}$ = Average value of level of agreements about "*The continuing "mutual learning" is employed in the relationship between industrial designer and engineer.*"

$$= (e_1 + e_2 + e_3 + \ldots\ldots + e_{27} + e_{28}) / 28 \quad (5)$$

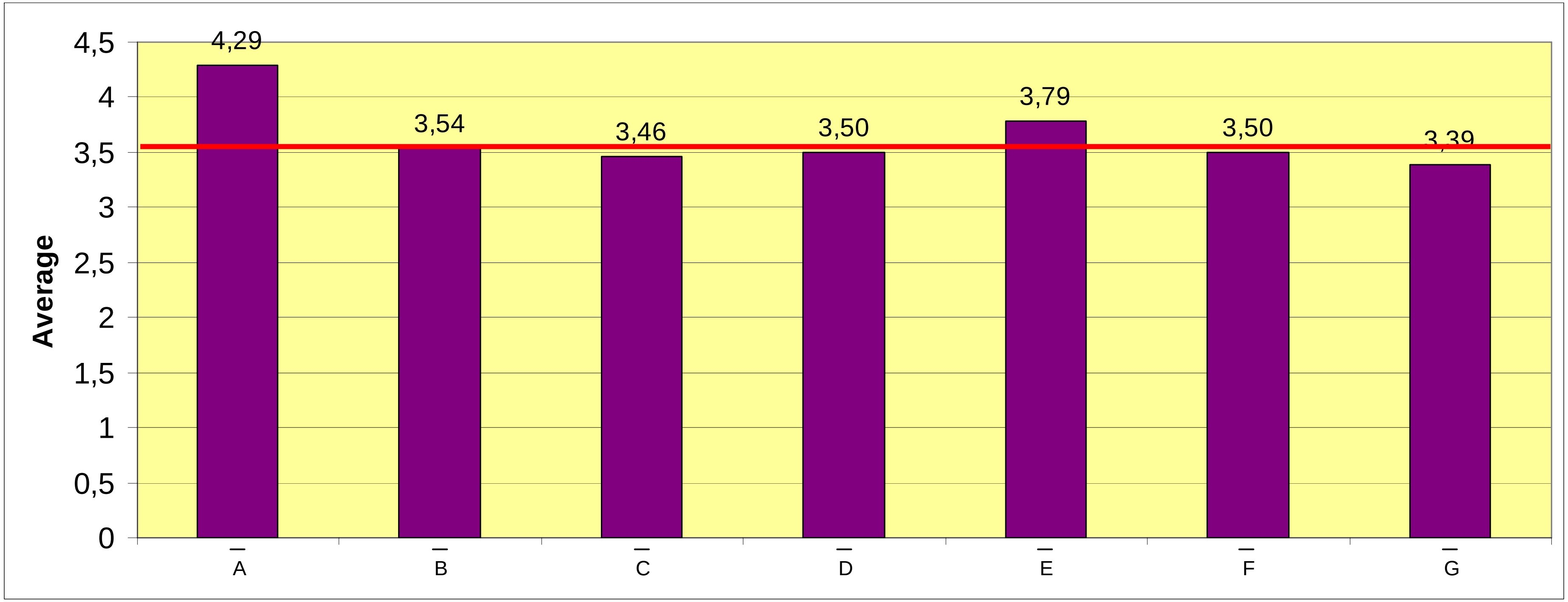
$\overline{F}$ = Average value of level of agreements about "*Engineers and industrial designers work in coordination in our team.*"

$$= (f_1 + f_2 + f_3 + \ldots\ldots + f_{27} + f_{28}) / 28 \quad (6)$$

$\overline{G}$ = Average value of level of agreements about "*The problem solving and decision making processes are performed by engineers and industrial designers in cooperation.*"

$$= (g_1 + g_2 + g_3 + \ldots\ldots + g_{27} + g_{28}) / 28 \quad (7)$$

The line in the figure illustrates the last statement's (respondent opinion about their product development team's performance) average value. The aim of this line is to illustrate the relation between team performance and the factors. It is clear that, average value of each factor is closer to the average value of the performances. This means that product development team's success is positively affected from those factors. Additionally, team leader's importance is seen very clear in the figure.




$\overline{A}$ = Average value of level of agreements about "*The affect of the team leader is high."*
$\overline{B}$ = Average value of level of agreements about "*Each team member has a clear and common idea about goals/objectives*."
$\overline{C}$ = Average value of level of agreements about "*The social communication between engineers and industrial designers in our product development team is very good.*"
$\overline{D}$ = Average value of level of agreements about "*The professional communication between engineers and industrial designers in our product development team is very good.*"
$\overline{E}$ = Average value of level of agreements about "*The continuing "mutual learning" is employed in the relationship between industrial designer and engineer.*"
$\overline{F}$ = Average value of level of agreements about "*Engineers and industrial designers work in coordination in our team.*"
$\overline{G}$ = Average value of level of agreements about "*The problem solving and decision making processes are performed by engineers and industrial designers in cooperation.*"

Figure 13. Average values of Likert-scaled statements

Another figure is prepared according to each respondent's answers to Likert-scaled statements (Figure 14). There are two lines in the figure. One of them (X) illustrates performance of product development team. This means, respondent's level of agreement about their team performance. For example, seventh respondent disagrees that "their product development team is successful in terms of its working performance", on the contrary sixteenth respondent strongly agrees on this statement. The other line (Y) illustrates average value of each respondent's level of agreement on the factors (seven statements in Likert-scaled statements).

Statistically;

$$Y_1 = (a_1 + b_1 + c_1 + d_1 + e_1 + f_1 + g_1) / 7 \quad (8)$$

$$Y_2 = (a_2 + b_2 + c_2 + d_2 + e_2 + f_2 + g_2) / 7 \quad (9)$$

…

$$Y_{28} = (a_{28} + b_{28} + c_{28} + d_{28} + e_{28} + f_{28} + g_{28}) / 7 \quad (10)$$

When the figure is analyzed, it is seen that these two lines are parallel and close to each other except three points (7., 8. and 13.). This means that, when the teams are observed one by one, performance of the team is positively affected from the factors searched in the literature. Namely, the following results can be gathered from this figure:

- Focusing on the relationship between engineers and industrial designers, leadership is an important factor affecting teamwork success.
- Engineers and industrial designers must have clear and common ideas about team's goals and objectives to achieve team success.
- Social communication between engineers and industrial designers must be good for an effective teamwork.
- Professional communication between engineers and industrial designers must be good for an effective teamwork.

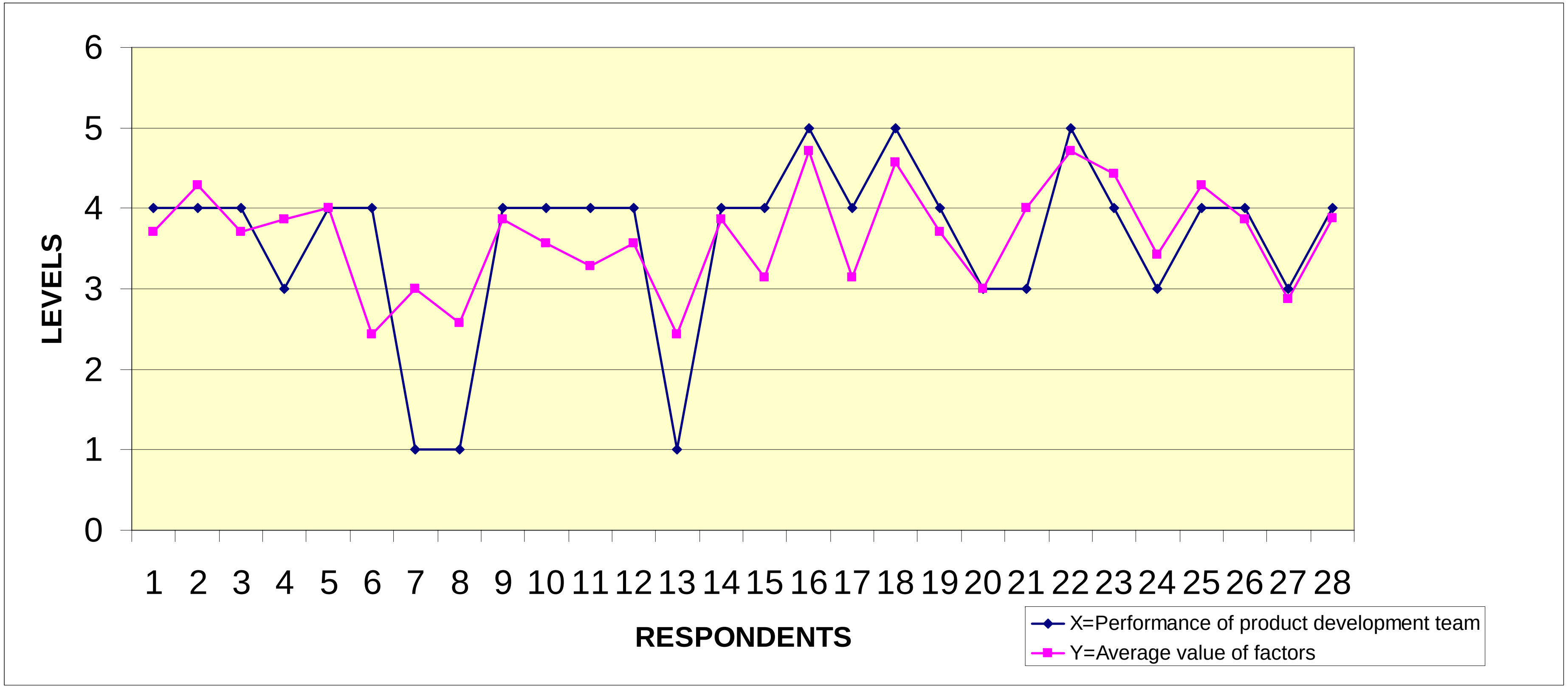



Figure 14. Relation between team performance and factors

- Engineers and industrial designers must learn about each other's knowledge, and experience for a successful teamwork.
- Engineers and industrial designers must work in coordination for an effective teamwork.
- The problem solving and decision making processes must be performed by engineers and industrial designers in cooperation.

These quantitative results gathered from Likert-scaled statements assist qualitative data that are gathered from open-ended questions.

As described in the earlier chapters, this study is based on a broad literature survey and a descriptive-survey study conducted to gather information about the effectiveness of teamwork on successful product development by focusing on the relationship between the team members –especially engineers' and industrial designers' relation. This chapter covers merely the results of these studies. Conclusions and implications are presented in the following chapter.

# CHAPTER 5

## CONCLUSIONS AND IMPLICATIONS

### 5.1 Conclusions of Literature Review Study

In the literature, effectiveness of teamwork on performing desired goals is expressed deeply from many researchers. Katzenbach and Smith (1993) investigated characteristics of teams. Wheelan (1999) searched the creation of effective teams. Robbins and De Cenzo (1998) conducted the effectiveness of teamwork. There is a lack of studies about negative effects of teamwork. Generally, many authors believe in the importance of teamwork on achieving success to reach the desired goals. There are also some studies on ‘unsuccessful teams’; for example, Robbins and Finley (1995) give answers to such questions with a matrix: “Why teams don’t work?” and “How to make it right”.

Companies are competing with each other to perform new product development. As the effects of teamwork are recognized by manufacturing companies, they form a group of people working as a team to develop new ideas, projects, and products which meet customer needs. Many research studies were conducted on the teamwork performances in product development processes. Rainey (2005) expresses the departments of participants of product development teams as engineering, design, technical, marketing, sales, support, production, process development, quality, and finance. According to Ettlie and Stoll (1990), it is obvious that in the phase of product and process design, engineers and industrial designers are only two of the key players for a successful product development. Mainly, with a broad literature review, effectiveness of teamwork for successful product development process by focusing on the relationship between the team members –especially engineers’ and industrial designers’ is investigated. Some of the aspects of teamwork are searched. Researcher encountered many studies on these aspects. The effects of cooperation, collaboration, coordination, communication, goal consciousness, collaborative problem solving and decision making, leadership, and learning team on the relationship between engineers and industrial designers for an effective product development process are investigated. Results of the literature study show that these aspects are the basic variables of teamwork which improve the effectiveness of teamwork.

## 5.2 Conclusions of Questionnaire Study

As mentioned before, a survey study is conducted to investigate the effectiveness of teamwork for a successful product development process by focusing on the relationship between the team members –especially engineers’ and industrial designers’ relation in Turkey.

The respondents of the questionnaire are engineers and industrial designers working together in product development teams of companies in Turkey. Their opinions on the aspects of teamwork in product development process, their level of agreements on the statements about the factors affecting teamwork, and the performance of their team are investigated. The answers of both groups are analyzed and compared with each other. Additionally, answers of all respondents are analyzed and summed up to show the current situation of engineer and industrial designer relation for effective product development teams in Turkey.

Results of the survey study show that average value of the population of the members in product development teams is 9,58. This result supports the findings of the research conducted by Quality Council of Indiana (2005) and Robbins and de Cenzo (1998); when structures of team types are examined, types of the respondent’s teams can be specified as ‘cross functional teams’ according to their structures and applications since they are formed of 8 to 12 members coming from different areas, departments, or disciplines.

Majority of the respondents' team leaders are 'engineers' (%64). Leader's profession might not be interrelated with team's success or failure according to researcher. Supportably, there are no studies in the literature that specially focused on the effects of 'profession' of the team leaders on team success. But this result only shows the distribution of team leaders' profession of respondent's teams.

Factors Affecting Product Development Team Success

Results of the open-ended questions of the study questionnaire show that; the most important factor affecting product development team success positively is "*cooperation*" according to respondents. As Zhuge (2003) states, cooperation between members determines efficiency and effectiveness of the team. Furthermore, according to the majority of the respondents, "*incoordination*" and "*being unsystematic*" are negative factors mostly affecting product development team success. As these terms are the opposites of 'coordination' and 'being systematic', researcher interprets this result as 'coordination' and 'systematical working' are important for an effective product development team. Researcher states that, a team needs coordination for managing processes, members, their skills and abilities, their efforts and actions for effectiveness.

As a noteworthy result, as percentages of "*time limitation*" and "*working environment*" is lower than other factors affecting product development team success, but when positive and negative sides of the answers are analyzed, it is found that limited time and poor working environment effect product development team's success negatively.

Factors Affecting the Engineer-Industrial Designer Relationship

Mainly, this study investigates factors affecting the engineer-industrial designer relationship for an effective product development team. Results show that, '*cooperation*' plays an important role on this relationship according to the majority of engineers. '*Being member of a learning team'* plays an important role on this relationship according to the majority of industrial designers. Collin (2002) states that members of the team can learn while doing the job itself, co-operating and interacting with colleagues, evaluating work experiences, taking over something new, having formal education, and doing extra-work contexts. Industrial designers also have some suggestions for sharing knowledge and experiences, and gaining some technical information from engineers. As a result, engineers and industrial designers believe in the importance of learning at work. Another attractive factor that rises from the results of the survey study is '*communication*'. Engineers and industrial designers have to communicate with each other to get feedback. The term 'feedback' is a frequently used term in the answers of the questionnaire. Both groups complain about 'lack of feedback'. They believe on the positive effects of feedback on the performance of product development team. As Wheelan (1999) expresses, feedback improves effectiveness and productivity. She also states, communication is needed for getting effective feedback.

As a noteworthy result, respondents believe that the '*job descriptions*' are highly affective on the engineer-industrial designer relationship. Although researcher did not get any finding on this subject in her literature survey. Most of the respondents of industrial designers and some of the respondents of engineers complain about uncertain job descriptions. Both groups should know their job descriptions, abilities, and capabilities for an effective relation. According to respondents, unclarity of job descriptions causes some conflicts in the teams. As in the literature, Robbins and Finley (1995) state "unresolved roles" which is an answer of the question, "why teams don't work?".

By considering the negative factors affecting the engineer-industrial designer relationship, questionnaire results are remarkable; '*individualism*' plays an important role on the relations according to most of the engineer respondents and some of the industrial designer respondents. Individual goals, jealousy, obstinacy, and individual competitions are mostly mentioned terms as the negative factors affecting the engineer-industrial designer relationship. Johnson and Johnson (1994) summarize two contrary approaches of group work in the literature. One of them is "individualistic orientation". In the characteristics of teamwork, the most important characteristic that separates 'teams' from 'groups' is; having a common purpose as Katzenbach and Smith (1993) expresses. Mainly, when individualism occurs, this means members are performing 'group work', not 'teamwork'.

Other issues that affect engineer-industrial designer relationship negatively are the '*conflicts on visual appeal and manufacturability*' between engineers and designers. Both engineers and industrial designers complain about these conflicts. They believe that the cause of these conflicts come from the educational background of each group. According to Cagan and Vogel (2002), designers give importance to shape and aesthetics whereas engineers give importance to cost and complexity. Additionally, Ettlie and Stoll (1990) summarize this relation as; designer explains the logic and the concept of the product, engineer explains if there is any complication in manufacturing of the design. As they mention in the answers of the questionnaire study, literature study also supports similar conflicts while describing the roles of each group.

Roles of Engineers and Industrial Designers

From engineer's view, the role of industrial designer is designing the product with a 'visual perspective' by giving importance to 'ergonomics' and 'aesthetics'. Majority of engineers use same definitions about the roles of industrial designers. But from the view of industrial designers, they haven't any common definitions as much as engineers have. They state similar terms which engineers express but additionally they give more detailed explanations about their roles in the team. For example, many of them express 'the importance of getting feedback from engineers' as one of the roles, but on the contrary only one engineer states 'getting feedback' from industrial designers.

From industrial designer's view, the role of engineer is 'designing manufacturing processes with the help of designer's feedback'. Majority of engineers define their own role as 'making technical analysis for finding solutions to functionality, workability and practicability'. All these definitions support the findings of the literature study about the roles of engineers and industrial designers in product development teams.

Product Development Process in Companies

Product development processes differ according to each company. Researcher could not reach a common structure for a staged product development process. As Rosenau and Moran (1993) state, every company customizes the stages according to the individual needs and its own culture. Only main structure of the stages is similar to the other companies; the process starts with concept stage, continues with development stage, and design stage, and ends with manufacture and launch stage. These stages are similar to Rosenau and Moran's (1993) staged product development. But researcher noticed different steps in different periods of time between the main stages of product development processes such as; 'feedback' and 'customer acceptance'.

Results of the Likert-scaled statements of questionnaire study corroborate the aspects of teamwork having effects on relationship between engineers and industrial designers for successful product development team scrutinized in the literature review study. The effects of leader, having clear and common goals, social and professional communication, sharing knowledge and experiences, coordination and cooperative problem solving and decision making processes on engineer-industrial designer relationship are positively related with the performance of product development team. It might be concluded that there is a direct relationship between these factors and the team performances. As Guzzo et al. (1995) express, team performance is affected from team leadership; the effects of leadership is the most obvious result of those Likert-scaled statements. Some noteworthy results on leadership are gathered from the comments of the Likert-scaled statements; respondents believe the 'effective' leader's team achieves success, but on the contrary, unsuccessful leader may cause the team to fail. Additionally, another comment is about leader's behaviors on both engineers and industrial designers. Respondents complain about the posture of the leader to each member of the team. Leader should be neutral against both engineer and industrial designer. This yields that the leader should have good interpersonal skills as Bean and Radford (2000) expressed.

## 5.3 Implications for Further Research

This study can be regarded as one of the rare studies on teamwork effectiveness for successful product development process by focusing on the relationship between the team members –especially engineers' and industrial designers'. As the results of the literature review and survey study show, there is a strong need to study the subject in detail for effective teamwork in product development processes.

This study investigates only the relationship between engineers and industrial designers in a product development team. Similar studies can be undertaken for searching the relation between industrial designers and the other members coming from different disciplines.

The survey study is applied to only engineers and industrial designers who are working in product development teams of companies working in different industrial areas. A further study can be performed on companies who work on the same industrial area for a critical study.

Product development teams have various members coming from different disciplines. Further studies can be undertaken that aim to gather the opinions of managers of the company, the leader and the other members of the team.

## 5.4 Concluding Remarks

As a result of this study, teamwork is a kind of collection that has some aspects affecting product development process positively or negatively. Accordingly, engineers and industrial designers who are the members of a product development team in a company, have to work in cooperation for achieving team success. Cooperative work needs effective communication to get feedback from each other. Feedbacks are subjected for a collaborative problem solving and decision making if the team has clear goals. Leader of the team yields engineers and industrial designers for coordinated work if they have clearly defined job descriptions. Learning from their knowledge and experiences at work improves the collaboration of engineers and industrial designers. Eventually for a successful product development process, an effective team might be built to perform all these aspects.

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# APPENDIX A

### ÖN E-POSTA

*(Turkish Version)*

Degerli Grup üyeleri;

ODTÜ Endüstri Ürünleri Tasarımı Bölümünde yürüttüğüm "Ürün Geliştirme Sürecinde Takım Çalışmasının Etkinliği: Mühendis-Tasarımcı İlişkisi" başlıklı yüksek lisans tez çalışması için ürün geliştirme takımlarında birlikte görev alan mühendis ve endüstriyel tasarımcıların görüşlerini almak istiyorum. Bu çalışma için -fazla zamanınızı almayacak- dört açık uçlu, sekiz çoktan seçmeli sorudan oluşan bir anket hazırladım. Eğer çok-meslekli ürün geliştirme takımlarından birinde yer alıyor, ve yaptığım çalışmaya katkıda bulunabileceğinizi düşünüyorsanız, anketi size iletebilmem için gozdepeh@yahoo.com adresime bir e-mail gönderebilirsiniz.

İlgi ve desteğinize şimdiden teşekkür ediyor, iyi çalışmalar diliyorum.

Gözde Pehlivan
Endüstri Mühendisi
ODTÜ EÜTB Yüksek Lisans Öğrencisi

## INTRODUCTORY E-MAIL

*(English Version)*

Dear Group members,

Within the scope of my MS thesis in METU Industrial Design Department; "Teamwork Effectiveness for Successful Product Development: Relationship between Engineers and Industrial Designers", I would like to get opinions of engineers and industrial designers who work together in product development teams. I prepared a short questionnaire with four open-ended and twelve Likert-scaled questions. If you are a member of a product development team (having multi-disciplinary members) and think you can make a contribution to my research, please reach me via e-mail at gozdepeh@yahoo.com.

I would like to thank you in advance for your interest and contributions.

Best regards,

Gozde Pehlivan
Industrial Engineer
MS Student of IDD in METU

# APPENDIX B

## İKİNCİ E-POSTA

*(Turkish Version)*

Öncelikle ilginize teşekkür ederim. Anket çalışmamı ekte tarafınıza gönderiyorum. Kişisel bilgileriniz gizli tutulacak, tez danışmanım dışındaki üçüncü şahıslarla paylaşılmayacaktır. Takımınızda çalışan diğer mühendis ve endüstriyel tasarımcılara da anketimin bir kopyasını iletirseniz çok memnun olurum. Onların da görüşleri değerli olacaktır.

İlgi ve katkılarınız için şimdiden teşekkür ediyor, iyi çalışmalar diliyorum.

Gözde Pehlivan
Endüstri Mühendisi
ODTÜ EÜTB Yüksek Lisans Öğrencisi

## SECOND E-MAIL

*(English Version)*

First of all, I would like to thank you for your interest. Please find the questionnaire attached to this message. Your personal data will be strictly kept in confidential and will not be disclosed to third parties, except my thesis advisor. I'd appreciate if you could pass a copy of my questionnaire to other engineers and industrial designers in your team. Opinions of you and your team members will be very precious for my research.

Thank you for your interest and contributions.
Best regards,

Gozde Pehlivan
Industrial Engineer
MS Student of IDD in METU

# APPENDIX C

## ANKET

*(Turkish Version)*

Aşağıdaki anket sorularına vereceğiniz cevaplar ODTÜ Endüstri Ürünleri Tasarımı Bölümü'nde yürütülen "Ürün Geliştirme Sürecinde Takım Çalışmasının Etkinliği: Mühendis-Tasarımcı İlişkisi" başlıklı yüksek lisans tez çalışması kapsamında yapılan bir araştırma için kullanılacaktır. Kişisel bilgileriniz gizli tutulacak, tez danışmanı dışındaki üçüncü şahıslarla paylaşılmayacaktır. Değerli katkınız için şimdiden teşekkür ediyorum.

Gözde Pehlivan

ODTÜ EÜTB Yüksek Lisans Öğrencisi

*Not: Bu anket çalışmasında sıkça sözü edilen "ürün geliştirme takımı": aynı firmada çalışan farklı meslek gruplarından elemanların -bilgi, beceri, deneyim, ve görüşlerini paylaşarak belirli bir ürünün tasarlanması/geliştirilmesi amacıyla- oluşturduğu çalışma grubunu ifade etmektedir.*

---

| Adınız, Soyadınız: | Mezun olduğunuz okul/bölüm: |
|---|---|
| Çalıştığınız firmanın adı ve faaliyet alanı: | |
| Firmanızda bağlı bulunduğunuz bölüm ve göreviniz: | |
| Ürün geliştirme takımınızı firmanızda nasıl adlandırıyorsunuz? | |
| Ürün geliştirme takımınız kaç kişiden oluşuyor ve meslek dağılımı nasıldır? | |
| Takım lideriniz varsa mesleği nedir? | |

Aşağıdaki dört açık-uçlu soruya istediğiniz uzunlukta cevap verebilirsiniz ya da sadece anahtar kelimeler kullanabilirsiniz.

| | | |
|---|---|---|
| 1 | Sizce bir ürün geliştirme takımının başarısını etkileyen olumlu ve olumsuz en önemli beş faktör nedir? | |
| | *(+)*<br>• ... | *(-)*<br>• ... |

| | | |
|---|---|---|
| 2 | Sizce ürün geliştirme takımlarında endüstriyel tasarımcı ve mühendislerin temel rolleri nelerdir? | |
| | *Tasarımcı*<br>• ... | *Mühendis*<br>• ... |

| | |
|---|---|
| 3 | Firmanızdaki ürün geliştirme sürecini kısaca nasıl tanımlarsınız? |
| | |

| | | |
|---|---|---|
| 4 | Başarılı bir ürün geliştirme süreci için mühendis-endüstriyel tasarımcı ilişkisini olumlu ve olumsuz etkileyen en önemli beş faktörü nedenleri ile yazar mısınız? | |
| | (+)<br>• ... | (-)<br>• ... |

Bu bölümde, verilen cümleler karşılığında takımınıza en uygun olduğunu düşündüğünüz kademeyi (X) ile işaretleyiniz. Her cümleden sonra boş bırakılan satırlara eklemek istediğiniz görüşlerinizi yazabilirsiniz.

| | | Kesinlikle Katılıyorum | Katılıyorum | Kararsızım | Katılmıyorum | Kesinlikle katılmıyorum |
|---|---|---|---|---|---|---|
| 5 | Takım liderimizin birlikte çalışma performansımıza **olumlu** etkisi yüksektir. | | | | | |
| | ... | | | | | |
| 6 | Takımımızın hedefleri/amaçları konusunda her üye açık ve net bir **ortak** fikre sahiptir. | | | | | |
| | ... | | | | | |
| 7 | Ürün geliştirme takımımızdaki mühendis ve endüstriyel tasarımcılar arası **sosyal** iletişim çok iyidir. | | | | | |
| | ... | | | | | |
| 8 | Ürün geliştirme takımımızdaki mühendis ve endüstriyel tasarımcılar arası **mesleki** iletişim çok iyidir. | | | | | |
| | ... | | | | | |
| 9 | Endüstriyel tasarımcı-mühendis ilişkisinde sürekli "**karşılıklı öğrenme**" (bilgi, deneyim, vs... paylaşımı) süreci etkindir. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ... | | | | | |
| 10 | Takımımızda mühendis ve endüstriyel tasarımcılar **koordineli** bir şekilde çalışırlar. | | | | | |
| | ... | | | | | |
| 11 | Bizim takımımızda problem çözme ve karar verme süreci mühendis-endüstriyel tasarımcı **işbirliğinde** yürüyor. | | | | | |
| | ... | | | | | |
| 12 | Birlikte çalışma performansımızı düşündüğümde, üyesi olduğum ürün geliştirme takımını başarılı buluyorum. | | | | | |
| | ... | | | | | |

Eğer bu araştırmanın sonuçları ile ilgileniyorsanız ve tarafınıza iletilmesini isterseniz, lütfen posta ya da e.posta adresinizi aşağıya yazınız.

# QUESTIONNAIRE

*(English Version)*

Your answers to the following questions will be used for a research within the scope of the MS thesis, "Effects of Teamwork in Product Development Process", conducted in the Department of Industrial Design at METU. Your personal data will be kept confidential and will not be disclosed to third parties, except the thesis advisor. I would like to thank you in advance for your time and precious contributions.

Gozde Pehlivan
Industrial Engineer
MS Student of IDD in METU"

*Note: The term "product development team", used throughout this document, refers to a working group established by employees of a company from different disciplines in order to facilitate an exchange of information, skills, experiences, and views and thereby design/develop a specific product.*

---

| Name, Surname: | Education (Department, University): |
|---|---|
| Name of your company and its main field of activities: | |
| Your department and position: | |
| Is there any specific name that you use for your product development team within your company? | |
| How many people are in your product development team and what are their professions? | |
| What is the profession of your team leader, if any? | |

Please write your answers to the following four open-end questions in the spaces below. You can use key words.

| | | |
|---|---|---|
| 1 | In your opinion, what are the most important five factors affecting the success of a product development team in both positive and negative ways? | |
| | *(+)*<br>• ... | *(-)*<br>• ... |

| | | |
|---|---|---|
| 2 | In your opinion, what are the main roles of industrial designers and engineers in product development teams? | |
| | *Designer*<br>• ... | *Engineer*<br>• ... |

| | |
|---|---|
| 3 | Please, briefly describe the product development process used in your company. |
| | |

| 4 | Please briefly describe the most important five factors affecting the engineer-industrial designer relationship within the product development process in both positive and negative ways, with their reasons. | |
|---|---|---|
| | (+)<br>• ... | (-)<br>• ... |

In this section, please put a cross mark (X) in appropriate boxes. You can use the space below each sentence for your comments.

| | | Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| 5 | The affect of our team leader in our work performance in a **positive** way is high. | | | | | |
| | ... | | | | | |
| 6 | Each team member has a clear and **common** idea about goals/objectives of our team. | | | | | |
| | ... | | | | | |
| 7 | The **social** communication between engineers and industrial designers in our product development team is very good. | | | | | |
| | ... | | | | | |
| 8 | The **professional** communication between engineers and industrial designers in our product development team is very good. | | | | | |
| | ... | | | | | |
| 9 | The continuing "**mutual learning**" (i.e. exchange of information, experience etc.) is employed in the relationship between industrial designer and engineer. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ... | | | | | |
| 10 | Engineers and industrial designers work **in coordination** in our team. | | | | | |
| | ... | | | | | |
| 11 | The problem solving and decision making processes are performed by engineers and industrial designers **in cooperation**. | | | | | |
| | ... | | | | | |
| 12 | In my opinion our product development team is successful in terms of its working performance. | | | | | |
| | ... | | | | | |

If you are interested in the results of this research, please specify your postal or e-mail addresses below in order to be informed.

# APPENDIX D

## PROFILE OF RESPONDENTS' COMPANIES AND PRODUCT DEVELOPMENT TEAMS

| Company | Main Field of Activities of Companies | Denomination of PDT | Number of Respondents | Education of Respondents | Population of PDT members | Profession of Members | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mechanical Engineer | Industrial Designer | Tech. Drawing and Machine Const. | Mechanical Technician | Electrical and Electronics Engineer | Electrical Technician | Aerospace Engineer | Technical Teaching | Industrial Engineer | Copmputer Engineer | Chemical Engineer | Materials Engineer | Physics | Civil Engineer | Architect | Engineer |
| Company 1 | Electrical Industry | Design Group | 2 | Mechanical Engineer<br>Tech. Drawing and Machine Const. | 3 | 2 | | 1 | | | | | | | | | | | | | |
| Company 2 | Electrical Industry | Project Team | 2 | Mechanical Engineer | 8 | 1 | 1 | | | 3 | | | | | 3 | | | | | | |
| | | Project Group | | Industrial Designer | | No comment | | | | | | | | | | | | | | | |
| Company 3 | Electrical Industry | Project Department / Industrial Design Department | 1 | Industrial Designer | 14 | 2 | 2 | 1 | | 1 | 5 | | | 3 | | | | | | | |
| Company 4 | Electrical Industry | R&D | 1 | Industrial Designer | 7 | No comment | | | | | | | | | | | | | | | |
| Company 5 | Automotive Industry | PD (Product Development) Team | 1 | Industrial Designer | 6 | 1 | 3 | 1 | 1 | | | | | | | | | | | | |
| Company 6 | Automotive Industry | No comment | 1 | Moulding Teaching | _ | No comment | | | | | | | | | | | | | | | |
| Company 7 | Automotive Industry | Engineering and R&D | 1 | Mechanical Engineer | 26 | 12 | 1 | | 9 | 1 | 3 | | | | | | | | | | |
| Company 8 | Automotive Industry | New Product Project Team | 2 | Industrial Designer | 9 | | 1 | 3 | | | | | | | | | | | | | 5 |
| | | New Product Project Team | | Industrial Designer | 9 | | 1 | 4 | | | | | | | | | | | | | 4 |
| Company 9 | Automotive Industry | Department | 1 | Mechanical Engineer | 3 | 2 | | | | | | 1 | | | | | | | | | |
| Company 10 | Steel Construction | Design Project Group | 2 | Mechanical Engineer<br>Mechanical Engineer | 4 | 4 | | | | | | | | | | | | | | | |
| Company 11 | Advertising Companies | Design Team | 1 | Industrial Designer | 8 | 1 | 4 | | | | | | | | | | | | 1 | 2 | |
| Company 12 | Advertising Companies | Innovators | 1 | Design and Construction Teacher | 3 | | 1 | | | | | | 1 | 1 | | | | | | | |
| Company 13 | Advertising Companies | Project and Product Development | 1 | Industrial Designer | 7 | 2 | 1 | 2 | | | | | 1 | 1 | | | | | | | |
| Company 14 | Caterpiller Manufacturer | Project 1, Project 2 , R&D | 1 | Mechanical Engineer | 27 | | 1 | 3 | | | | | 3 | | | | | | | | 20 |
| Company 15 | Electronics | R&D | 1 | Industrial Designer | 14 | | 7 | 1 | | | | | | | | | | | | | 6 |
| Company 16 | Electronics | R&D | 1 | Industrial Designer | 200 | x | x | | | x | | | | | | | | | | | |
| Company 17 | Electronics | Department of Product Development and Design | 1 | Mechanical Engineer | 7 | 3 | | 1 | | 2 | | | | | | 1 | | | | | |
| Company 18 | Electronics | Department of System Design and Mechanical Design | 2 | Industrial Designer | 200 | x | 5 | | | x | | x | | | | x | | x | | | |
| | | Project Team | | Electrical and Electronics Engineer | 80 | | x | | x | x | | | | | x | | | | | | |
| Company 19 | R&D | Group (Group of Fuel Battery) | 1 | Machinary (Voc. Sch. Of H. Education) | 9 | 1 | | | 1 | 2 | | | | | | 4 | 1 | | | | |
| Company 20 | Refining Industry | PD (Product Development) Team | 1 | Mechanical Engineer | 7 | 3 | 1 | 1 | | | 1 | | | 1 | | | | | | | |
| Company 21 | Refining Industry | Department of Project and R&D | 1 | Mechanical Engineer | 3 | 1 | 1 | 1 | | | | | | | | | | | | | |
| Company 22 | Construction Industry | Product Development Department | 1 | Industrial Designer | 28 | | x | x | | | | | | | | | | | | | x |
| Company 23 | Cooling Systems Industry | The Most Dynamic and Innovator Department of the Company | 1 | Industrial Designer | 8 | 3 | 1 | 3 | 1 | | | | | | | | | | | | |

x: undefined quantities