# UNDERSTANDING COLLABORATIVE ACTION IN EMERGENT WORK ECOSYSTEMS: MAKERSPACES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ÖZCAN KEKLİK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
INDUSTRIAL DESIGN

SEPTEMBER 2021

Approval of the thesis:

**UNDERSTANDING COLLABORATIVE ACTION IN EMERGENT WORK ECOSYSTEMS: MAKERSPACES**

submitted by **ÖZCAN KEKLİK** in partial fulfillment of the requirements for the degree of **Master of Science in Industrial Design Department, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar
Dean, Graduate School of **Natural and Applied Sciences** ______________

Prof. Dr. Gülay Hasdoğan
Head of the Department, **Industrial Design** ______________

Assist. Prof. Dr. Yekta Bakırlıoğlu
Supervisor, **Industrial Design Dept., METU** ______________

**Examining Committee Members:**

Assist. Prof. Dr. Senem Turhan
Industrial Design Dept., METU ______________

Assist. Prof. Dr. Yekta Bakırlıoğlu
Industrial Design Dept., METU ______________

Assist. Prof. Dr. Aykut Coşkun
Media and Visual Arts, Koç University ______________

Date: 10.09.2021

**I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.**

Name, Last name : Özcan Keklik

Signature :

# ABSTRACT

## UNDERSTANDING COLLABORATIVE ACTION IN EMERGENT WORK ECOSYSTEMS: MAKERSPACES

Keklik, Özcan
Master of Science, Industrial Design
Supervisor: Assist. Prof. Dr. Yekta Bakırlıoğlu

September 2021, 150 pages

As the design problems confronted are getting more complex, the necessity of different expertise becomes inevitable for comprehensive design solutions which indicate the importance of forming teams with professionals from diverse disciplines. With the emergence of collaborative teams, the importance of working frames has become prominent, and collaborative working frames have been introduced, namely interdisciplinary, multidisciplinary, and transdisciplinary. These working frames determine the type and level of interaction between professionals, espousing various opportunities and challenges. Apart from traditional working environments, there are emergent work ecosystems – such as makerspaces – that involve varying collaborative structures in terms of organizational, spatial, and social dimensions. This study investigates the collaboration dynamics in makerspaces through these dimensions and aims to analyze the new collaboration mindset, methods, and toolkits provided by makerspaces. Understanding the makerspace elements and their effects on the collaborative activity will contribute to setting up novel collaboration models. In the scope of the research, in-depth interviews with both makers and makerspace facilitators were conducted and collaborative action in makerspaces was analyzed considering organizational, spatial, and social elements through the experiences and insights of the participants. Based on the analysis of the gathered data, three main conclusions were drawn. Firstly, makerspaces introduce a non-disciplinary collaboration environment where interest-driven knowledge blurs the disciplinary fields. Secondly, tangible means produced in these making-oriented spaces become tools that enhance learning collaboratively. Lastly, drivers of the collaboration vary among makerspaces as goal-driven or place-driven collaborative making.

Keywords: Collaboration, Maker Movement, Coworking Spaces, Makerspaces, Disciplinarity

## ÖZ

## GELİŞEN YENİ ÇALIŞMA EKOSİSTEMLERİNDE İŞ BİRLİĞİNİN ANLAŞILMASI: YARATIM ATÖLYELERİ

Keklik, Özcan
Yüksek Lisans, Endüstri Ürünleri Tasarımı
Tez Yöneticisi: Dr. Öğr. Üy. Yekta Bakırlıoğlu

Eylül 2021, 150 sayfa

Karşılaşılan tasarım sorunları gittikçe karmaşıklaştıkça, farklı disiplinlerden profesyonellerle ekip oluşturmanın önemini gösteren kapsamlı tasarım çözümleri için farklı uzmanlığa duyulan ihtiyaç kaçınılmaz hale gelmektedir. İşbirlikçi ekiplerin ortaya çıkmasıyla birlikte, çalışma çerçevelerinin önemi öne çıkmış ve disiplinler arası, çok disiplinli ve disiplinler ötesi olmak üzere işbirlikçi çalışma çerçeveleri tanıtılmıştır. Bu çalışma çerçeveleri, profesyoneller arasındaki etkileşimin türünü ve düzeyini belirler, çeşitli fırsatları ve zorlukları destekler. Geleneksel çalışma ortamlarının yanı sıra, örgütsel, mekansal ve sosyal boyutlar açısından farklı işbirlikçi yapıları içeren yaratım atölyeleri gibi yeni çalışma ekosistemleri de ortaya çıkmıştır. Bu çalışma, yaratım atölyelerindeki işbirliği dinamiklerini bu boyutlarla araştırmakta ve yaratım atölyeleri tarafından sağlanan yeni işbirliği zihniyetini, yöntemlerini ve araçlarını analiz etmeyi amaçlamaktadır. Yaratım atölyeleri öğelerini ve bunların işbirlikçi etkinlik üzerindeki etkilerini anlamak, yeni işbirliği modellerinin oluşturulmasına katkıda bulunacaktır. Araştırma kapsamında hem yaratım atölyeleri üyeleri hem de hizmet sağlayıcıları ile derinlemesine görüşmeler yapılmış ve katılımcıların deneyimleri ve içgörüleri aracılığıyla yaratım atölyelerinde örgütsel, mekansal ve sosyal unsurlar göz önünde bulundurularak işbirlikçi eylemler analiz edilmiştir. Toplanan verilerin analizine dayanarak üç ana sonuç çıkarılmıştır. İlk olarak, yaratım atölyeleri ilgi alanına dayalı bilginin disiplin alanlarını bulanıklaştırdığı disiplin dışı bir işbirliği ortamı sunar. İkincisi, bu yaratım odaklı alanlarda üretilen somut nesneler öğrenmeyi işbirliği içinde geliştiren araçlar haline gelir. Son olarak, işbirliğinin itici güçleri, hedef odaklı ve yer tabanlı işbirlikçi yapım olarak yaratım atölyeleri arasında farklılık gösterir.

Anahtar Kelimeler: İş Birliği, Maker Hareketi, Ortak Çalışma Alanları, Yaratım Atölyeleri, Disiplinerlik

Only Makers left alive.

**ACKNOWLEDGMENTS**

First and foremost, I would like to express my deepest gratitude to my supervisor Assist. Prof. Dr. Yekta Bakırlıoğlu for his continuous support, guidance, and encouragement throughout this challenging process. His feedbacks and motivation were valuable for me to widen my perspective. Even we could not complete the study together, I also would like to thank Assist. Prof. Dr. Pınar Kaygan for her guidance at the beginning of this study.

Besides my supervisor, I would like to thank the rest of my thesis committee: *Assist. Prof. Dr. Senem Turhan* and *Assist. Prof. Dr. Aykut Coşkun* for their valuable contributions.

I would like to thank one of my best friends Duygu Vatan for her endless support, and guidance. It was very valuable to talk and discuss with her throughout this challenging process. She made me feel confident and excited throughout the process.

I would like to thank my master colleagues Lilyana Yazirlıoğlu, Melis Dursun, and Ayşe Kaplan for their support and advice.

I would like to thank my friend Gülberg Çelikel. She is a motivation booster and makes me feel that I can accomplish.

Lastly, I want to thank my parents, especially my sister Nalan Keklik, for their understanding and support throughout this process.

## TABLE OF CONTENTS

## LIST OF TABLES

TABLES

## LIST OF FIGURES

FIGURES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Humanity is confronted with complex design problems that require joint efforts of various disciplines (Bronstein, 2003). This collaborative action takes many forms according to the level of integration among these disciplines as; multidisciplinary, cross-disciplinary, interdisciplinary, and transdisciplinary (Dykes et al., 2009). Van den Besselaar and Heimeriks (2001) emphasize the necessity of integrated approach that synthesize various scientific disciplines to generate an application–oriented knowledge. With the blurred definitions of disciplines, non-standard forms of employees emerge in business life. People who have specialized in their practice started to find new working frameworks which accommodate knowledge professionals (Gandini, 2015). Coworking spaces are collaborative communities that are used by knowledge professionals; such as entrepreneurs, freelancers, makers, fabbers, hackers (Mitev et al., 2019). These places provide familiarization and collaboration among individuals, opinions, and shared areas as an emergent social platform (Merkel, 2015).

Among coworking spaces, makerspaces exhibit a distinctive collaboration environment with its *making*-oriented structure. The act of making, a unique feature of humanity, is defined as the way of transforming the world using tools and materials (Dougherty, 2016). Anderson (2012) explains the new industrial revolution into two parts: discovering online and making it in reality. The digital revolution is mainly restricted to screens, in which laptops, phones, TVs enable connection with the outer world. However, we live in our physical worlds that are surrounded by manufactured items. Although Maker Movement is defined as a movement that supports hobbyist and school projects, it has a significant impact on social and economic change (Martin, 2015). While conventional production gathers people under hierarchical control and management, peer production brings people together with the rise of networked systems and online platforms to generate collective intelligence (Benkler, 2015).

The business, education and social aid models evolve through the increased availability and accessibility of digital fabrication tools (eg. 3D printers, laser cutters, CNC machines) (Gershenfeld, 2012). Now, there are makerspaces founded in various forms, academic makerspaces, library-based makerspaces, or museum-based makerspaces. In these varying contexts, makerspaces are places where production can be democratized through collective making activities with shared facilities (Mersand, 2021). In this community-based environment, it is possible to access tools, collaborators, and skills to make anything desired. Through the dissemination of *making*, shared tools and methodologies enable a product/item designed and fabricated in one makerspace to be produced as-is or adapted/customized in any other makerspaces (Smith, 2017). Means created in makerspaces do not have a single owner since it emerges from a collaborative effort of many individuals in dispersed communities (Benkler, 2015). Dougherty (2016) define maker mindset as the tangibles that are gained from experiences along maker activities. This mindset is disseminated over communities with the Maker Manifesto introduced by Hatch (2014). It creates a guidance for the maker community with presenting the core values of makers as make, share, give, learn, tool up, play, participate, support, and change. Within this shared environment, collaboration takes different forms according to the particular elements of makerspaces.

## 1.2 Aim and Scope of the Study

Many individuals who are inclined to create their own artifacts search for spaces to work. These areas provide both shared facilities and an environment that encourage people to use the makerspaces. It is not only about facilities or environment to use, but also these spaces provide a social environment that consists of people from diverse areas both exhibiting the eagerness to make. This familiarity in desire and diversity in practices create a social setting that people act and share in the community. In the context of emergent makerspaces, there are various applications in high schools, university campuses, public libraries, or museums. In Turkey, it is widely seen that applications in universities, high schools, pre-schools, and public spaces are common. In order to investigate collaborative action in these settings, the main focus was university makerspaces and public makerspaces aiming at social benefit, since these spaces provide a disciplinarily diversified environment. This study aims to reveal how members of the community collaborate in these makerspaces with respect to the organizational, spatial, and social aspects.

## 1.3 Research Questions

Regarding the mentioned aim of the study, the following research questions are asked.

- How and to what extent do the collaboration characteristics change in relation to the particular elements of makerspaces?
- What are the effects of organizational, spatial and social elements of makerspaces on collaborative activities through the thoughts and experiences of makerspace members?
- How and to what extent does the collaboration among participants differ in changing makerspace contexts?

## 1.4 Significance of the Study

There are changing frameworks with the advanced technologies and social settings in work environments. In these evolving work environments, some professionals position themselves in the creative field. While designers follow with the change in these frameworks, makerspaces provide an innovative setting that contains collaboration and maker movement together.

When collaboration literature is examined, it is seen that literature is more gathered around practices in management, design, and medical fields. It is seen that these studies centralize knowledge management, role sharing, and disciplinarity while discussing collaboration. In the defined borders of disciplinary frameworks, levels of collaboration are discussed through the disciplinary knowledge and intertwined areas. In recent years, emergent studies of coworking spaces put forward the social and spatial aspects of collaboration in creative work fields. There are studies that investigate the experiences and interactions of members within these socially enhanced spaces. However, these areas are used by more freelance individuals or small scale company workers. In this context, a coworking space becomes just a common use space that provides a social environment for independent members.

In the maker movement literature, there are studies mostly in education, engineering, technology, and production fields. There are studies more focused on the case studies that investigate the design of new makerspaces in schools. Most of these studies present guidance to establish new makerspaces mostly in terms of production facilities; however, the disciplinary concept is not probed. In addition, implementations of both open hardware and open software into the technological initiatives by students or entrepreneurs are emphasized. Effects of these technological improvements on integrating individuals into the production are mentioned as well, yet there is not much discussion about ways of collaboration in these studies.

In this study, investigating collaboration elements from the perspective of both members and facilitators of the space is significant. Differentiating from other coworking spaces, makerspaces consist of members and facilitators who show similarities in their perspectives and aims. Also, the uses of makerspaces differ from other spaces with the provided fabrication environment rather than just a shared office.

This study contributes to the discussion around collaboration in the maker movement literature with a comprehensive approach examining the organizational, spatial, and social aspects. The findings of this study introduce an understanding of design management practice while examining the collaborative design action in disciplinary diversified areas.

A significant percentage of people who use coworking spaces are designers. Considering design education, the use of design studios can be interrelated with the makerspaces considering its shared use and making-oriented space. However, disciplinarity cannot be mentioned in the context of design education. Since design discipline is positioned as a central discipline that has interfaces with many fields, it is important to explore making-oriented shared spaces through the lens of disciplinarity. Therefore, it is significant to analyze these relations to make contributions to both design of coworking areas and the enhancement of design education.

## 1.5 Structure of the Thesis

This thesis is structured into five main chapters.

Chapter 1, Introduction, establishes a ground for the study while explaining briefly background studies related to collaboration and the emergence of makerspaces. Then, the aim and scope of the study, research question, and significance of the study are stated. Lastly, the structure of the thesis throughout the five chapters is given briefly.

Chapter 2, Literature Review, presents a comprehensive overview of the literature on both collaboration and the maker movement. The literature on collaboration is examined under four main headings; disciplinary frameworks, organizational aspects of collaboration, spatial aspects of collaboration, and social aspects of collaboration. The second part of the literature starts with the maker movement. Then disciplinary frameworks discussed in these environments are given. After that, collaboration characteristics in makerspaces are presented under organizational, spatial, and social frames.

Chapter 3, Methodology, begins with the methodological approach adopted in this study. Then, the sampling strategy is described and the selected participant groups are introduced. After that, the data collection process is explained through the used techniques, interview questions, and the procedure of conducting interviews. Finally, the data analysis method, template analysis, is explained step-by-step.

Chapter 4, Analysis, presents the results of interviews. First of all, the involvement process of members to the space is outlined by introducing their personalities, expectations, and also the attitude of makerspace facilitators while inviting members. Then, collaboration characteristics in the makerspaces are analyzed under organizational, spatial, and social frames. Another layer of the analysis provides a comparative approach while examining collaboration. Both goal-driven and place-driven makerspaces are compared to underline the differentiating collaboration characteristics, followed by a comparison of the participants' previous work experiences and their makerspace experiences.

Chapter 5, Conclusion, begins with an overview of the study. Then, the main conclusions of the study are listed and discussed further. Limitations confronted through study and recommendations for further research are presented lastly.

# CHAPTER 2

# LITERATURE REVIEW

In this chapter, a literature review of the relevant topics covering the aim and scope of this study is given.  The purpose of this literature review is to establish a ground for the research which investigates the collaborative environment of the makerspaces as a new working framework. While investigating the collaboration in makerspaces, a comparative approach is used with business-oriented environments. In the literature review given in this chapter, there will be two main sections that describe the collaboration characteristics both in business-oriented working environments and makerspaces. Business-oriented working environments are explained within their disciplinary frameworks and collaboration characteristics. After that, the overview of Maker Movement, disciplinarity in makerspaces, and the collaboration characteristics are given in detail.

The review starts with collaboration frameworks as defined as *multidisciplinary*, *interdisciplinary*, and *transdisciplinary*. Collaboration in business business-oriented working environments will be investigated considering its *organizational*, *spatial*, and *social* dimensions. After that, the maker movement will be described with the definitions and history of the movement. Then, disciplinary frameworks in makerspaces will be examined to understand their disciplinary nature. Similarly, collaboration characteristics will be investigated under three main sections: *organizational*, *spatial*, and *social* aspects that affect collaboration in makerspaces.

## 2.1 Collaboration Characteristics in Business-Oriented Working Environments

As problems studied in the design fields are getting more complex, the solutions for these problems requires diverse design related expertise (Arias et al., 2000). While bringing this diverse expertise, coordination of a team is essential to construct a common ground in coordinated design activity (Barron, 2000). Fischer (2004) defines design as a ubiquitous activity, which is situated at the core of creative occupation and emphasizes the necessity of working collaboratively rather than individual work.

Although the necessity of collaboration in design activities is stated, its emergence into the work field is changing with time. Boundaries between design-related disciplines are blurring (Dykes, Rodgers & Smyth, 2009). According to types of knowledge transfer along these borders, collaboration takes many forms as; multidisciplinary, interdisciplinary, cross-disciplinary, and transdisciplinary. These different forms create new frameworks for collaborative design settings. While these different frameworks are based on disciplinary relations, there are other variables such as spatial, social, or organizational aspects which define a collaborative action and dependently evolve the collaborative working framework. (Poggenpohl, 2004). Now, makerspaces are the new form of the collaborative working framework which differs from traditional working environments (Hyysalo et al., 2014).

### 2.1.1 Disciplinary Frameworks

In order to understand the nature of collaboration, it is required to examine *discipline* and different disciplinary frameworks. Throughout this section, disciplinary frameworks will be defined to clarify the forms and levels of collaboration. Responding to the aim and scope of this research, it is necessary to position business-oriented working environments and makerspaces considering these frameworks.

#### 2.1.1.1 Disciplinarity

Gardner (2000) defines discipline as a professional domain that exhibits its own concepts and methods related to specific fields. These disciplinary domains consist of scholars who represent shared culture (Kuhn, 1970). Reich and Reich (2006) define these cultures as academic tribes regarding their interaction, social relations, methodologies, attitude, and value.

Van den Besselaar and Heimeriks (2001) state that with the growing complexity of problems, a single scientific discipline cannot generate a single, comprehensive solution. Synthesis of various scientific disciplines is required to gather *application-oriented knowledge* to develop an applicable solution. Gibbons et al. (1994) classify the production of knowledge as two modes, regarding their disciplinary environment. Mode 1 is the disciplinary knowledge, which consists of theoretical knowledge based on academic interest. Mode 2 is more application-oriented, rather than focusing on specific scientific knowledge. To create an environment that supports the production of knowledge, it is essential to provide a basis for communication and coordination of various disciplines. Jantsch (1972) specifies collaboration forms in a hierarchical order from disciplinarity to the following frameworks as multidisciplinarity, pluridisciplinary, cross-disciplinary, interdisciplinary, and transdisciplinary. In the following sections, multidisciplinary, interdisciplinary, and transdisciplinary collaboration will be presented in detail.

#### 2.1.1.2 Multidisciplinary Collaboration

Collin (2009) defines multidisciplinarity as a collaboration framework where various disciplines working independently on different tasks of a common project. This collaborative action has a parallel or sequential task order. Disciplinary actions are done in the disciplinary boundaries and there is no attempt to generate complementary knowledge (Tress et al, 2005). Stock and Burton (2011) classify multidisciplinary collaboration as a coordinated but not integrated activity. Although disciplines have interaction in order to maintain a coordinated project, it does not become an integrated activity among different disciplines. Nicolescu (2005) states that there is the independence of disciplines and multidisciplinary collaboration continues as a disciplinary work even in the achieved collaborative environment.

#### 2.1.1.3 Interdisciplinary Collaboration

Interdisciplinarity is defined as the integration of knowledge and perspective of two or more disciplines in order to solve a complex problem (Repko, Szostak & Buchberger, 2020). This approach aims to generate more comprehensive insight while studying a problem. Stock and Burton (2011) draw a comparison of interdisciplinarity and multidisciplinarity addressing the level of integration and cooperation. Interdisciplinary studies require bridging among disciplinary perspectives in order to achieve an integrated and cooperative working environment. This bridge makes it possible to generate new knowledge with the contribution of neighbouring disciplines aiming for a jointly framed problem, methodology, and solution.

#### 2.1.1.4 Transdisciplinary Collaboration

Dykes (2009) classifies transdisciplinary collaboration as the most complex form of collaborative frameworks because of its focus on complicated real-world problems. Stock and Burton (2011) states that apart from the integration of various disciplines, transdisciplinarity enables participatory design with the attendance of stakeholders and practitioners of related problems. Domik and Fischer (2011), emphasize how transdisciplinary collaboration differs from multidisciplinarity and interdisciplinarity. In multidisciplinary collaboration, disciplines work on the same problem in sequential order cooperatively, whereas interdisciplinary collaboration takes it one step further with an integrated knowledge created together. On the other hand, transdisciplinarity enables collaboration to generate new knowledge with purpose-oriented disciplinary joint work. Klein (2000), describes this form of collaboration as a 'newly unified whole' since collaboration becomes independent from disciplines; and also, disciplinary approaches and knowledge are merged. With the achieved collaboration, it is not possible to distinguish disciplinary concerns or expertise (Gibbons et al., 1994).

### 2.1.2 Organizational Characteristics of Collaboration

From an organizational point of view, collaborative working environments are shaped according to two main concepts: *openness* and *governance*. While openness refers to the interaction within team members, governance is more related to the relative hierarchical status among participants. As illustrated in Figure 2.1, the combination of the open-closed or flat-hierarchical structure determines the level of collaboration between team members and directly affects the design process on an organizational level. Collaboration modes defined by these factors change throughout the design process depending on the project and participants (Salonen, 2012).

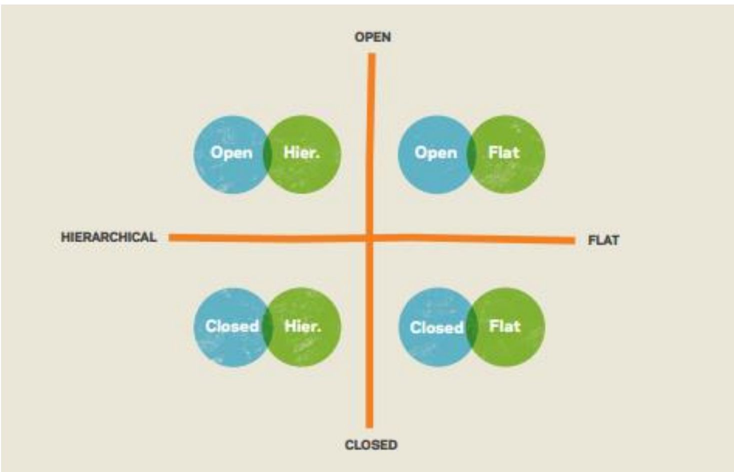



Figure 2.1 Openness and Governance of Collaboration (Salonen, 2012)

#### 2.1.2.1 Governance of Collaboration

Organizational flatness is defined as the reduced organizational levels resulting in independence in operations. This non-hierarchical structure provides a flexible environment in the organization (Zhang et al., 2014). Informality among different levels contributes to the collaborative environment where creativity, integration, and flexibility are required (Claver-Cortés, Zaragoza-Sáez, & Pertusa-Ortega, 2007). It also enables more efficient communication among all participants through a decentralized decision-making process. As a result of this flat organizational structure, all participants are engaged to take part in the collaborative design process (Huang et al., 2011).

#### 2.1.2.2 Openness of the Collaboration

Organizational openness is defined as the ease of accessibility to an organization and its related tasks. Rather than a predefined set of roles, openness in the organization enables individuals to take responsibility and have a voice while asking for a task. There is no appointed role from the managers or team leaders. In open organizations, participants could make contributions easily but subject areas in open structures are not specific, as opposed to closed structures. In closed structures, the field of study is well determined, and experts in the fields are chosen by managers or team leaders (Salonen, 2012).

#### 2.1.2.3 Organizational Knowledge Management

Jakubik (2008) states that participants within an organization are intended to learn and share knowledge considering closeness in space and context. It is also stated, organizational learning is not achieved with the written sources but also roles, practices, perspectives, and beliefs of that organization (Claver-Cortés, Zaragoza-Sáez, & Pertusa-Ortega, 2007). According to Smith (2001), knowledge shared and generated in an organization can be classified into two main categories:, tacit knowledge and explicit knowledge.

Linde (2001) explains tacit knowledge as a hidden source that exists in the individual's mind. It is the knowledge that arises from the behaviours, perspectives, expertise, and abilities of the individual. In an organizational context, tacit knowledge transfers the way of doing a specific task within social interactions. Also, Smith (2001) describes tacit knowledge as 'know-how' based on the practice of individuals. She interprets tacit knowledge as a clash of different disciplines, cultures, and topics resulting in a 'creative chaos'. Secondly, explicit knowledge is the knowledge that can be transmitted among individuals through formal language (Linde, 2001). In addition, Smith (2001) describes explicit knowledge as 'know-what' which differs from tacit knowledge considering its distribution. Using the academic knowledge or approach, individuals can digest explicit knowledge given in printed or online sources.

Garvin (1993) describes learning in the organization with the notion of '*five building blocks*'. He introduced five categories to learn as (1) scientific learning, (2) trials and errors, (3) learning from previous experiences, (4) peer learning, and (5) knowledge transfer (Table 2.1).

Table 2.1 Five Building Blocks of Organizational Learning (Garvin, 1993)

| Building Blocks | Description |
|---|---|
| Scientific Learning | Scientific methods are used to solve problems. Accuracy and precision is critical |
| Trials and Errors | Experimentations are carries out to generate new knowledge |
| Learning from previous experiences | Individual experiences or history evaluated to understand the reasons for success or failure. |
| Peer learning | Experiences of others used to adapt solutions or generate new ideas |
| Knowledge transfer | Written or oral sources used to transfer knowledge through reports or trainings |

Learning in an organization is not gathering diverse knowledge of required disciplines, but scaling that knowledge through the organization with a shared understanding (Fiol, 1994). According to Moreira and Zimmermann (2012), individuals' sense of belonging to a community is a key element while sharing knowledge with other members of the organization. Commitment to the organization makes individuals comfortable while sharing their knowledge and thoughts. However, the knowledge sharing environment in the organization also brings a perception of compromise and conflict. Comparing the shared perspectives with their opinions causes individuals to have an attitude while communicating (Werr, Blomberg, & Löwstedt, 2009).

#### 2.1.2.4 Decision Making

Competing values arise from individuals' perspectives, knowledge, and experiences belonging to their disciplines. Bucciarelli (1988) defines this problem as an 'object world'. He states that languages and representations belonging to each discipline become an obstacle during communication between team members and hampers the creation of shared understanding. Arias et al. (2000) state that these conflicts should be taken as an opportunity for the generation of new ideas rather than obstacles. Chen et al. (2014) introduce the methodology to understand negotiation characteristics in multidisciplinary collaborative design. Members of the studies represent their own disciplines; therefore, they tend to consider their own utility. However, the negotiation process in collaborative works requires concession to improve overall utility. With the iterative negotiation process, disciplines remove the conflicts and reach a consensus that provides a satisfying solution for all team members.

### 2.1.3 Spatial Characteristics of Collaboration

According to Capdevila (2017), space creates a medium for collaboration among motivated individuals for creative projects while enabling peer learning. Ciolfi and

Bannon (2007) approach to the notion of space as a framework that enables interaction of individuals in a physical environment. Mitev et al. (2019) define collaborative spaces as working environments that present a flat collaboration with its provided: ambience, spatial order, aesthetic codes,  and resources.

Kallio et al. (2015) emphasize the importance of physical space and distance. As the physical distance between desks and offices enlarges, interaction among workers becomes difficult and alternative communication methods are used. Even walls, separators or doors become obstacles for face-to-face communication. Also, Kokkonen et al. (2018) point out the importance of the workstation layout. While designing work areas, open-plan offices are preferred to increase the visibility of individuals.

#### 2.1.3.1 Coworking Spaces

Coworking spaces are described as an emergent form of social platforms, which provide familiarization and collaboration among individuals, opinions and connecting environments (Merkel, 2015). Capdevila (2017) defines coworking spaces as meeting points where people with common interests come together. These places enable them to work on projects while having interactions with the other creative users of the space.

Coworking spaces become prominent with the sharing economy, the high number of self-employed workers or freelancers, increased demand for flexibility, and the use of advanced technologies (Weijs-Perrée et al., 2019). From the perspective of a shared economy, makerspaces can be regarded as large, open-to-use offices divided into shared desks for their members. Services given in the space, such as meeting rooms, lounge or kitchen, are shared too. Flexibility is provided both in terms of time and desk according to individuals' calendars. (Leforestier, 2009). Weijs-Perrée et al. (2019) classify the users of the space as freelancers, self-employed people, workers, entrepreneurs, small and medium medium-sized enterprises (SMEs), workers of corporate firms, or students. Members of the space locate the working environment in between social and professional life that presents opportunities for both social and professional interaction.

In the context of coworking spaces, Mitev et al. (2019) state that, around the interaction points such as kitchen, coffee machine, and resting areas, tacit knowledge is gathered and distributed within the community culture.

#### 2.1.4 Social Characteristics of Collaboration

Arias et al. (2000) state that complex design problems require the expertise of various people rather than a single individual. Therefore, it is necessary to form a social environment that consists of different stakeholders and their collaborative interactions. The diversity of stakeholders bring different cultures together that present different standards and demonstrations.

There is a shift from individual to collective working since the diversity of team members enables the development of creative solutions with collective intelligence (Brazdauskaite & Rasimaviciene, 2015). They emphasize that collective intelligence initiates the process of creativity which can be defined as the combination and integration of existing knowledge, experience, and approach in order to generate new ideas.

##### 2.1.4.1 Shared Understanding

Cannon and Salas (2001) investigate the collaborative action as explaining the term ‘what is shared’. According to their classification, four main categories of ‘shared’ are *task-specific knowledge*, *task-related knowledge*, *peer knowledge*, and *approach/opinion*. In a social context, it is possible to generate comprehensive design solutions when the approach and opinions of the individuals are shared. Shared approach and opinion is a more general attitude enabling cohesion and consensus through collaborative study. It spreads over the whole process independent from any task.

#### 2.1.4.2 Social Ties

Cumming and Kiesler (2008) define the working relationship among participants as collaborative tie strength which means a joint individual effort to achieve a common goal. This is directly related to the concept of proximity, homophily, and familiarity. Proximity is the physical distance between team members to maintain communication and has a positive effect on collaborative tie strength. Homophily is the ease of effective communication between members of similar characteristics such as education, belief or age. These similarities improve the likelihood of working together and empower the collaborative tie strength. Also, getting used to one's habits and preferences makes team members more familiar and their interactions become more comfortable.

A collaborative community is formed when strong social ties among individuals are observed as a sense of community (Baek, Meroni, & Manzini, 2018). Malone and Crowston (1990) describe coordination among team members as harmony. Barron (2000) states that coordination is possible when an integrated team is observed to establish a common ground.  Chaurasia et al. (2020) define value as a belief that is possessed by a group of people, culture or an individual. When the value is shared among people and organizations, shared value is formed for that specific community in order to achieve the collaborative goal.

Until now, collaboration in business-oriented working environments is introduced. Disciplinarity and its varying frameworks are presented to specify the levels and ways of collaboration. Then, collaboration characteristics are investigated under three main headings (i.e. organizational, spatial, and social). In the following section, makerspaces as collaborative working frameworks will be introduced. In order to familiarize with the maker movement literature, the following section will start with narrating the emergence of the movement, makers, and their mindset. Also, disciplinarity in makerspaces and conversations about the frameworks are shared. Lastly, collaboration characteristics are analyzed through the organizational, spatial, and social aspects of makerspaces.

## 2.2 Maker Movement and its Collaborative Aspects

The activity of making differentiates humanity from other animals. In Latin, the person who has the ability of making is designated as *"Homo Faber"* which means *"Man the Maker*". *Homo Faber* has the ability to make tools from materials to change the world around (Dougherty, 2016). Making is defined as the exploration of how things work through creating or shaping objects (Honey and Kanter, 2013). Halverson and Sheridan (2014) approach the term of making as an activity to create means while accomplishing goals along the process.

Nascimento and Polvora (2018) state that there are also related terms, such as hacking, tinkering, fabbing, and crafting, as the variations of productive activities which have different use of tools, materials, space and community. The concept of *hacking* has the contradictory act of creating means toward the existing usage or environment. The process of hacking starts with breaking down things to understand how they work and continues with producing new and extraordinary objects (Nascimento & Polvora, 2018). *Tinkering* is described as a playful, experimental and exploratory approach to a problem or task. The tinkering process is the continuous generation of ideas, examining and improving the concepts, then experimental investigation of concepts in a progressive way. In opposition to planning, it is more of a messier process. The tinkering process begins with messing around with things. With a bottom-up approach, it enables people a playful exploration and building of new things over the objects (Resnick & Rosenbaum, 2013). In order to manufacture an object, conventional production facilities use the methods of shaping, carving or sticking. *Fabbing* is the production of objects from digital files with the emergent use of rapid prototyping facilities, such as 3D printers, laser cutters (Burns &

Howison). Gibson (2019) describes craft as a process in which a skilled practitioner exhibits mastery of materials and techniques while making an object. Although there are human imperfections in craft, these products have value in terms of meeting both personal and social needs. Also, the relationship of the craftsman with the cultural and social environment is reflected in these means.

Then who is the maker? According to Kalil (2013), makers are the people who allocate their own time to design and produce things. They find it satisfying to make, tinker, explore, interpret and distribute using their accumulated experience. Menichinelli et al. (2007) made the definition of 'maker' as the person who carries out the design and manufacturing of the physical artifacts from electronics to craft.

In the following section, the Maker Movement will be explained with its history, emergence to the new digital era, and its scalability among society.

### 2.2.1 Maker Movement

Although the term Maker Movement is heard widely in recent years, there have been former developments back at the end of the 20th century. With the emergence of personal computers and technological facilities, both free time occupation and social independence through making is enabled (Lindtner, Hertz, & Dourish, 2014). Martin (2015) also states that, while the maker movement is seen as a movement that supports school or hobbyist projects with digital fabrication tools, above all it is the initiator of a social and economic change. After Dale Dougherty launched Make Magazine in 2005, the maker movement became recognized in society. The magazine becomes became a source of encouragement for people to start a new hobby or gain new skills (Dougherty, 2012). In the following year, 2006, Maker Faire was held which became the space where readers came together and spread this movement with the enhanced learning environment and community (Dougherty, 2012). Further, Maker Faires have spread as annual events around the world in order to provide makers with a display area of what they made (Peppler & Bender, 2013).

Hynes and Hynes (2018) describe the Maker Movement as a movement that gathers people together to reveal their imagination and passion to create through collective learning and making. Martin (2015) defines the Maker Movement as the community of hackers, hobbyists, tinkerers, and craftsmen who design and produce playful and functional objects. The Maker Movement influenced the future of both technological and cultural tendencies. Emerging technological facilities enable affordable and easy production, to create and share both physical and digital artefacts. Also, the maker movement changes the direction of personal consumption characteristics from using mass-produced goods to prioritizing personally produced items. Makers started to feel the pleasure of creating artefacts with the do-it-yourself (DIY) approach entering their lives (Resnick & Rosenbaum, 2013).

In terms of scalability of the Maker Movement, shared sources of knowledge, cheap hardware, and accessibility of digital fabrication make it possible to reach the potential makers (Halverson & Sheridan, 2014). Von Hipple (2005) states that the *'democratization of innovation* is enhanced with the innovative individuals who create products or services for their own use. Hatch (2014) also emphasizes that the power of this movement is directly related to its democratizing nature of making which supports the idea that 'everyone can make' (Hatch, 2014, p.15) and 'everyone can change the world' (Hatch, 2014, p.30).

The following section introduces the Maker Manifesto and the maker mindset, which are the guidelines of the makers' collective movement.

#### 2.2.1.1 Maker Manifesto and the Maker Mindset

Maker Manifesto is published by Mark Hatch in order to create guidance for the community. Hatch (2014) defines the core values of the maker community as make, share, give, learn, tool up, play, participate, support, and change. These core values are published and other makers are called to make changes and personalize their own maker movement manifesto.

Creating new ideas and converting these into tangible things has an impact on both the maker's life and the world. This level of control over life through the creative process develops maker mindsets. Maker mindset is the intangibles that are gained from experiences along making activities (Dougherty, 2016). Martin (2015) lists four main elements of the maker mindset as playful, asset and growth-oriented, failure positive, and collaborative:

> **Playful:** Although the Maker Movement is related to the emergence of fabrication tools, cheap and accessible materials and online sharing platforms, the experimental play takes place on the top. Having fun, attention, and play is situated at the core of making. The learning process of both children and adolescents can be enhanced via playful activities (Martin, 2015).
>
> **Asset and Growth-oriented:** Dougherty (2013) identifies a maker mindset as growth-oriented that everyone can learn anything they want to achieve. They can both improve their areas of expertise or dive into new fields where they are motivated to learn (Martin, 2015).
>
> **Failure Positive:** Failure is welcomed within the maker mindset considering its opportunity to build experience. It is important to understand the problems faced in order to establish adaptive proficiency (Martin, 2015).
>
> **Collaborative:** Collaboration and sharing are key elements of the maker mindsets. Sharing enables knowledge transfer, feedback mechanisms and social relations within the community. Even if the maker projects are not carried out in groups, collaboration is possible with an environment that facilitates sharing ideas and helping each other. Maker movement can be interpreted as a knowledge building community with its macro-scale sharing and collaborating nature (Martin, 2015).

In the previous section, making as a creative activity is defined with the definition of a maker. Then, the Maker movement is explained historically with its emergence and scalability in society. After that, Maker Manifest and the mindset that makers develop is presented to clarify the individual characteristics. In the following section, the definition and classification of makerspaces will be presented.

#### 2.2.1.2 Makerspaces

The emergence of makerspaces changes in size and type. A common point for all of the makerspaces is its spatial divergence of bringing experts, ideas, tools, and knowledge together. Rather than providing a variety of tools, the "act of making" remains at the core of makerspaces (Davee, 2015). Taylor et al. (2016) define makerspaces as the reflection of maker culture, which provides personal production facilities such as digital fabrication tools and open electronics located into openly accessible spaces. They interpret this change as a revolution in collective working environments. Burke (2014) summarizes the makerspace as anywhere making happens. He emphasizes the act of making regardless of space. In line with this perspective, Davee (2015) classifies makerspaces into three main categories where 'making' appears in different contexts:

**Dedicated Makerspaces:** These makerspaces include production facilities, materials, and tools in a specific location such as libraries or schools.

**Distributed Makerspaces:** Rather than spatial use, distributed makerspaces are organization-oriented. The core of these makerspaces is the members of the organization and its governance. Various locations are used for events, production, and meetings by the makers.

**Mobile Makerspaces:** In this context, space and facilities are mobile and making activities can be held in different locations.

Vuorikadri et al. (2019) define makerspaces' four quadrants in order to demonstrate the different contexts of making with the changing spatial and learning practices. The horizontal driver of change is the use of dedicated space that integrates their mindset in a physical setting. Maker programs are carried out in museums or libraries where space is not dedicated to a specific community. On the other hand, the vertical driver of the change is the intended goal of the makers. The use of space along with scheduled training activities, such as workshops or learning in the space, while experiencing the space are two poles of this axis. These four quadrants classify the makerspaces that offer different contexts of making as given in Figure 2.2.

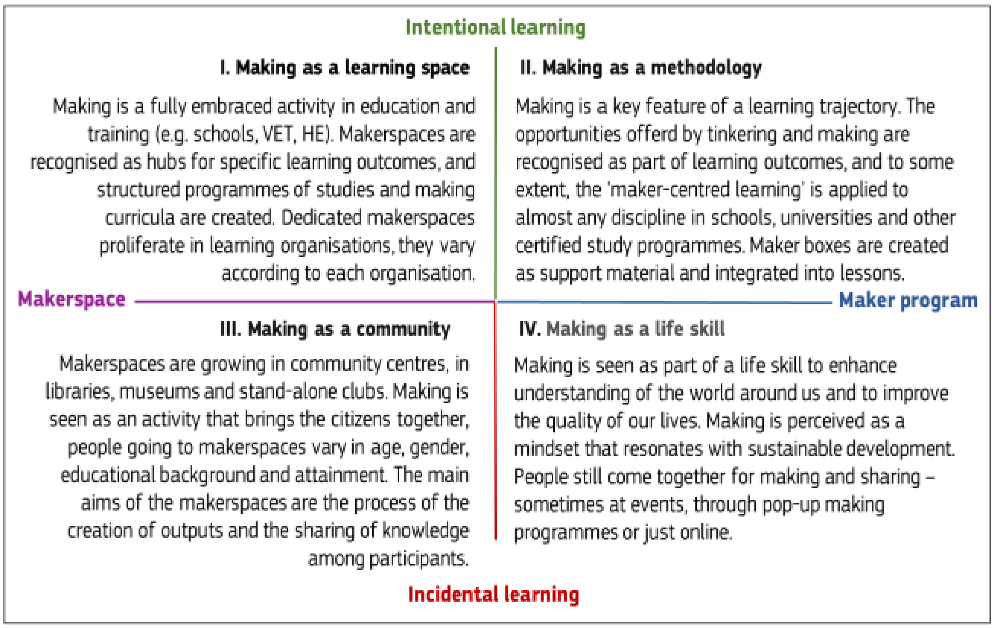



Figure 2.2 Four Quadrants of Making (Vuorikari et al., 2019)

Makerspace definition and its emergence in different contexts is given above. In the following section, disciplinarity in makerspaces will be analyzed.

### 2.2.2 Disciplinarity in Makerspaces

The Maker Movement initially emerged with the Maker Faires and independent organizations, such as TechShop, and Sector 67. After that, this movement spread to museums, schools, libraries, university clubs and local communities (Halverson & Sheridan, 2014). In these different settings, Vuorikari et al (2019) point out that makerspaces encourage 'making' in divergent disciplines. Although the disciplinary perspective is given and practised in academic life, diverse disciplines, such as art, engineering, and design, bring their disciplinary skills and knowledge together to produce creative things. In makerspaces, disciplines tend to observe and shift to another disciplinary field to gain its perspective.

Güler et al (2017) define makerspaces as both cross-disciplinary and multidisciplinary. In these collaborative environments, rather than experiencing different fields, individuals also learn how to interact with makers from different fields. Mathuews and Harper (2018, p.359) describe makerspaces as 'discipline-neutral, informal learning spaces'. Byrne and Davidson (2015, p.10) claim that "making erases disciplinary boundaries... or transcends them". It enables interdisciplinary collaboration between diverse disciplines, such as engineering, designs, art, and science, by removing physical and mental boundaries. Thus, disciplines have the chance of getting to know each other in a creative and goal-oriented way. Halverson and Sheridan (2014) state that makerspaces remove the disciplinary borders with the nature of their process and product-oriented practices. The main focus of the projects are tools, materials, and processes.

Foth et al (2018) analyze the disciplinary framework of the makerspaces in three dimensions where the disciplinary boundaries are blurred and blended with transdisciplinary linkages. First of these dichotomies arises from the concepts of professionals and amateurs. Even though making requires a set of skills, makerspaces involve professionals to educate amateurs to reach common goals. Secondly, fabrication in makerspaces brings both digital and physical skills together in order to create things that involve various disciplinary skills. Lastly, makerspaces bring craft culture and knowledge-based disciplines together. While craft culture is associated with *'blue-collar'* skills, knowledge-based disciplines are associated with academic, *'white-collar'* skills. Makerspaces enable the integration of these two socially categorized groups to catalyze the possible sharing of different perspectives.

### 2.2.3 Collaboration Characteristics in Makerspaces

In the previous section, disciplinarity arguments in makerspaces are given to present the collaborative action. As Poggenpohl (2004) states, collaboration characteristics in makerspaces can be investigated under three main headings; organizational, spatial, and social aspects. Firstly, the organizational structure of makerspaces considering members, hierarchy, and knowledge management will be introduced. After that, spatial elements including physical and digital tools in the space are explained with their effects on collaboration. Interactions among both human and non-human actors in space are demonstrated. Finally, social aspects of makerspaces and their effect on collaboration are presented emphasizing the participation, sense of belonging to the community, and collective learning environment.

#### 2.2.3.1 Organizational Effect on Collaboration

Dougherty (2016) emphasizes that, besides space, it is critical to build an organization in order to maintain the making activities in the space. Considering how makerspaces should be governed, He emphasizes the importance of managerial responsibilities and decision-making processes in space. Makerspaces exhibit a self-organizing structure rather than hierarchical communities.

#### 2.2.3.1.1 Participants of Makerspaces and Hierarchical Orders

Dougherty (2016) illustrates the pyramid of participation while explaining the community's expertise and hierarchical structure (Figure 2.3). The base of the pyramid represents the amateurs which are many in number. These people have the eagerness to progress with the activities even though most of their attempts remain unachieved. However, professionals, the upper portion of the pyramide, are relatively small in number but they prove themselves with their expertise in the field. While professionals are called paid personnel, amateurs are mostly called volunteers in the community.

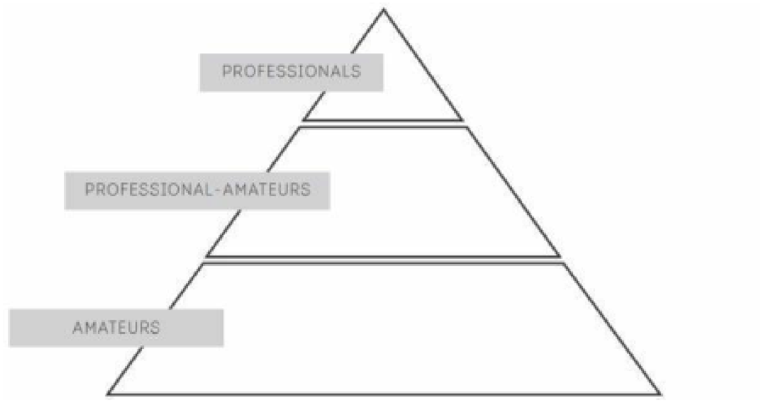



Figure 2.3 The Pyramid of Participation (Dougherty, 2016)

In the context of makerspaces, there is a blended proficiency that breaks down the hierarchical order among participants. Contrary to the expected flow of competence from bottom to top, amateurs have the opportunity to get paid for a task, or professionals may dive into new areas where they love to be. Halverson and Sheridan (2014) define the work in the makerspaces as voluntary, unlike school education. In makerspaces, the field of study, the time of work, the process to follow are totally up to the maker's' individual working manner. Young participants in the space are welcomed and their opinions are valued in the organization; thus, encouraging them to show their individual skills and methods (Davee et al., 2015).

In order to understand the organizational structure of the makerspaces, it is necessary to define its members. According to Dousay (2017), there are three main categories; paid personnel, volunteers, and a blend of two. Davee et al. (2015) make a classification of makerspaces members as *spacemakers* and participants. The term *"spacemaker"* corresponds to educators and responsible people for running the makerspace. Since makerspaces take different forms in universities, local and corporate organizations, their participants vary greatly. Another classification of makers by Jensen et al. (2016) describe these subgroups as entrepreneurs, hobbyists, children, students, and companies.

Dougherty (2016) draws attention to the agility and scalability of the Maker Movement with the aid of removed hierarchical orders. According to him, amateurs are the driver of the Maker Movements. Without asking permission from professionals, amateurs take the initiative and perform experimental processes to do tasks in the makerspaces. It provides freedom for amateurs to improve themselves and contribute to the agility of this movement. Byrne and Davidson (2015) state that making surpasses the traditional hierarchy of the dissemination of information and opposes academicians, student, and faculty authority. Regardless of these hierarchical titles, individuals are engaged to learn from each other in makerspaces.

#### 2.2.3.1.2 Learning Practices in the Organization

Vuorikari et al. (2019) point out that in terms of their aims and approaches, makerspaces take different forms. While some of the makerspaces concentrate on social innovation, others may concentrate on empowering particular groups, entrepreneurship, or education in schools. It is essential to investigate learning practices in these varying forms of the Maker Movement's implementation areas. Although it seems that application in schools requires an intensive study on education and learning, these practices are enlarged to other domains where *"making*" is shared.

Martin (2015) makes a comparison of learning practices in traditional classrooms and makerspaces considering the interaction of members. While in traditional classrooms, there is a direct flow of information from teacher to students, interaction in makerspace is more complex. This interaction occurs around the makers' work in a multidirectional way.

Learning practices in the makerspaces situated at the junction of constructionism, constructivism, problem-based learning, and collaborative learning. The main difference between constructionism and constructivism is the way of knowledge transfer instructively or intuitively (Dousay, 2017). In the constructivist approach, learning occurs in a social manner where learning from other makers or experts occurs. It is not a lesson taught by an instructor; rather, it is the gathering of required learning materials through communication in a social context (Tan et al., 2016). Besides, the constructionist approach emphasizes the process of learning something while making. With the digital and physical making facilities of the makerspaces, knowledge is constructed through experimentation, tinkering and questioning along the process (Halverson & Sheridan, 2014). Moreover, collaborative learning is possible in environments where two or more individuals come together. In the makerspaces that provide this work environment, makers gather knowledge about a topic and enhance their skills to produce. In order to achieve collaborative learning, it is necessary to have community knowledge, community interaction, and the eagerness of individuals to learn (Oswald & Zhao, 2021). Finally, Dousay (2017) defines problem-based learning as the key element which enables the maker to frame an ill-structured problem or investigate an unpracticed activity of creation. Along the process of problem-based learning, makers follow four main steps; problem presentation, problem examination, solving the problem and problem assessment (Chan & Blinkstein, 2018).

In order to maintain these approaches in the makerspaces, there is a need for educational principles that makerspace organizations should follow. Kurti et al. (2014) list these principles as accepting failure, encouraging the use of equipment without fear and collaboration. Besides its facilities, makerspaces should provide a supportive environment for makers to sustain their attendance in the community. Failure is seen as an opportunity to explore new things and reach desired goals in an iterative way. The process of digesting knowledge through lessons learned is encouraged. Secondly, the most remarkable aspect of the makerspaces is their digital and physical fabrication capabilities. The use of this equipment without fear enables makers to be more productive in the makerspace. Lastly, collaboration is valued in order to gather diverse knowledge and expertise together. Space-makers govern the collaborative environment by initiating and encouraging debates. As a multiplier, space-makers bring individuals together in order to create a valuable reflection from individual opinions.

Wardrip et al. (2015) relate the learning practices of the makerspaces with its practice-based perspective. This approach is based on the social and cultural context of learning through practicing in makerspaces.  In parallel with the given learning practices above, practice practice-based learning shows similarities with both collaborative learning and constructivist approach in a social manner. With the diverse environment of the makerspaces, including various disciplines and levels of expertise, makers practice in a social environment that supports peer learning. Also, practice-based learning shows similarities with both constructionist and problem-based learning approaches in a cultural manner. Maker culture gives priority to questioning the problem, tinkering, presenting a failure positive attitude, and a growth-oriented approach.

#### 2.2.3.2 Spatial Characteristics

Makerspaces are built within the context of education, public use or corporate organizations. “Making” is encouraged within the libraries and museums located in these areas (Herro et al., 2021). Sheshadri et al. (2018) emphasize the effects of space on community engagement. While makerspaces bring people with common interests together, they also provide a platform that supports social cohesion. It is possible to meet other makers, share projects, and hang out in the space. Keune et al. (2015) point out that collaboration occurs within the makers and physical and social elements around. Apart from interaction among individuals, interaction occurs with the help of physical artefacts which enable shared investigation and practice.

##### 2.2.3.2.1 Fabrication Tools in the Space and their Reflection on Collaboration

Keune et al. (2015) classify the tools for making as low-tech and high-tech tools. Low-tech tools such as scissors, wrenches or measurement tools are placed in common use areas and it is possible to shift these from one desk to another. Also, high-tech tools, such as 3D printers and laser cutters, are placed in the space to enable rapid use. Printing materials or laptops used for the data transfer become the gathering point for makers that boost social cohesion. Anderson (2012) defines digital fabrication tools as four desktop factories (i.e. 3D printers, laser cutters, CNC routers, and 3D scanners). Usage areas and work principles of these digital fabrication tools are presented below:

**3D Printers:** In order to print a model, it is necessary to create 3D models generated via CAD (Computer-Aided Design) software or 3D scanning. With the slicer tools, 3D models are sliced into virtual layers. The printing process continues layer by layer. Printing material, in the filament form, is deposited from a nozzle which is a melting head (Martin, 2015).

**Laser Cutters:** The cutting process is initiated with the melting of the raw material with a laser head. Raw materials used for laser cutting are generally thin layers of wood, plastic, or metal. Laser head moves in 2D coordinate systems. Desired geometry is projected into a 2D drawing which determines the path of the laser (Martin, 2015).

**CNC Routers:** Apart from 3D printers and laser cutters, CNC routers produce desired objects by removing material from raw material. In order to produce a model with a CNC Router, it is necessary to create a 3D model. Using the CAM (Computer-Aided Manufacturing) software, this model is converted to a path in a 3d coordinate system. Also, various cutting tools are used to remove material. Speed of these tools is also critical for machining. Raw materials used in CNC routers vary from wood, metal to plastic (Martin, 2015).

**3D Scanners:** Besides 3D printers, laser cutters, and CNC routers, which are the machines that fabricate 3D objects, 3D scanners convert real objects into digital 3D files. With the light source objected to an item from all around, it is possible to generate 3D models of everything someone possesses (Anderson, 2012).[A26]

Keune et al. (2015) reveal how accessibility, mobility, and flexibility of tools enhance collaborative learning and remove social obstacles. Both high and low-tech tools are placed in visible and unlocked locations without any restriction to the makers. To illustrate, Taylor et al. (2016) symbolise 3D printers as a 'hook' that draws the attention of the makerspace visitors, thus enabling the interaction around it.

All around these physical and social interaction points which makerspace provides, it is also a synthesizer of different fields. Traditionally separated disciplines gather together under the roof of makerspaces with the creative *"making*". With the diversity in terms of both spatial objects and makers' interest in the space, someone makes sewing while someone deals with electronics nearby or woodworking next to computer programming. It is also noticed that traditional and digital making activities share the same space which enables creative combinations of disciplinary knowledge and hand skills (Mitev et al., 2019).

In their study, Taylor et al. (2016) point out the importance of a variety of fabrication elements in the makerspace to scale up the collaboration there. While, in common, makerspaces possess digital fabrication tools and electronics, these facilities determine the level of diversity in the space. Including sewing equipment in the makerspace enables creative juxtapositions since it draws the attention of a different community. Therefore, the interaction of various spatial elements and makers who are from diverse interest areas enrich the collaboration and sharing of knowledge in the space.

##### 2.2.3.2.2 Makerspace as a Third Place

Mitev et al. (2019) describe makerspaces, rather than a physical area, as a space, a time and a community standing between home and work (i.e. third place). In the case of educational makerspaces, it is also seen as a space that combines formal and informal learning practices with the facilities and the mindset presented by teachers and *space-makers*. Collective learning is enhanced in these third spaces with eagerness-oriented attendance, collaboration, and the social relation between makers (Culpepper & Gauntlett, 2020). Also, it is noted that these places provide their users with a supportive environment and strong commitment (Gerdenitsch et al., 2016). Consequently, makers value their effort, have a taste of freedom and feel connected to a community in contrast to corporate workplaces (Spreitzer et al., 2015).

Rafalow (2016) mentions that makers enlarge their making activities from creating tangible objects to programming, graphical design or electronics that are shared in the online spaces. These platforms will be given in the following chapter to explain the social community that the maker movement achieved.

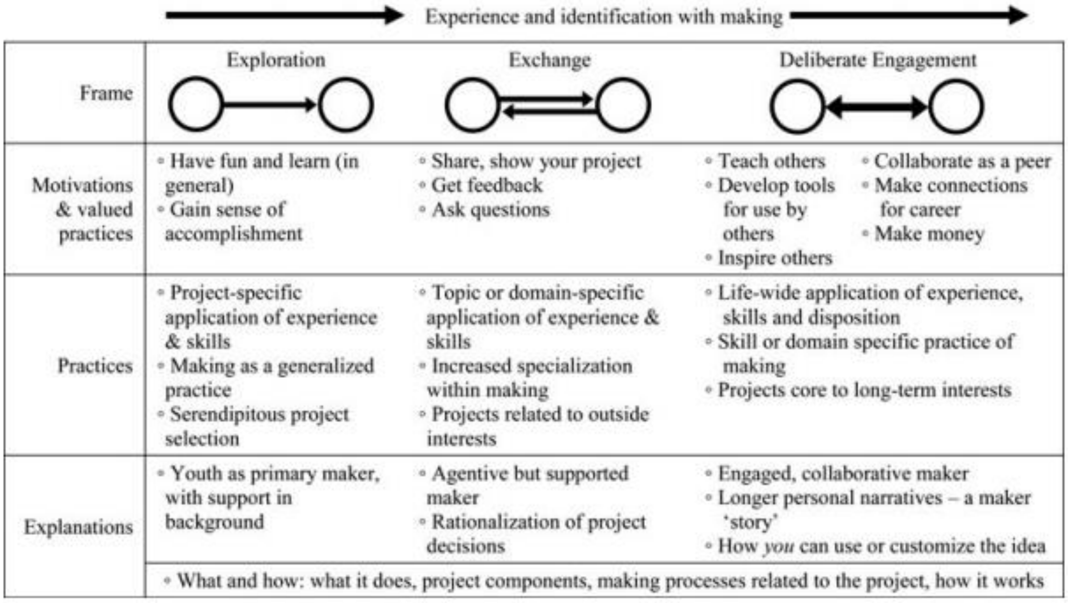
#### 2.2.3.3 Social Characteristics of Makerspace

Apart from a space where fabrication activities are done, makerspaces are *'hubs of community'*. In this community, makers socialize while working and learning together (Taylor et al., 2016). Wilczynski et al. (2016) also state that makerspaces gather makers together around social events and design workshops in order to create social cohesion. Hatch (2014) states that makerspaces play a junctor role in gathering like-minded people together to make projects. Apart from the disciplinary divergence of the makerspace members as described in the previous sections, makerspaces involve people from various socio-economic backgrounds, ethnicities, genders, and disabilities. Although the maker stereotype is noted as white, male middle-class individuals, there are women, people of different colours, and the homeless in the makerspace which present diverse social identities (Riley et al., 2017).

According to Wilczynski et al (2016), community-centered spaces are open and supportive environments that foster participation, a sense of belonging to the social environment and collective learning. While there is no obstacle to access to space, new members are welcomed to join collaborative making. Also, social links among makers are enhanced with the social programs and attachment to the community increases with the raised community awareness. Lastly, the learning process is supported by peer learning and collective knowledge building.

#### 2.2.3.3.1 Participating a Community

Makers from diverse social entities follow an involvement process in a community. Dixon and Martin (2014) classify frames of involvement as exploration, exchange and deliberate engagement (Figure 4). It is a process of experiencing and identification with making in the community. Firstly, participants aim to have fun and learn something in the makerspace. It starts with the sense of achieving the act of making. With the developed knowledge and experiences, makers intend to interchange their know-how with peer-to-peer conversations, sharing projects, and giving critiques to each other. Finally, intentional involvement begins with the developed collaborative mindset in the community. At this level, makers become experts in the field and teach other makers, develop tools for community use, and inspire others to improve the community.



| → Experience and identification with making → | | | |
|---|---|---|---|
| Frame | Exploration | Exchange | Deliberate Engagement |
| Motivations & valued practices | • Have fun and learn (in general)<br>• Gain sense of accomplishment | • Share, show your project<br>• Get feedback<br>• Ask questions | • Teach others<br>• Develop tools for use by others<br>• Inspire others<br>• Collaborate as a peer<br>• Make connections for career<br>• Make money |
| Practices | • Project-specific application of experience & skills<br>• Making as a generalized practice<br>• Serendipitous project selection | • Topic or domain-specific application of experience & skills<br>• Increased specialization within making<br>• Projects related to outside interests | • Life-wide application of experience, skills and disposition<br>• Skill or domain specific practice of making<br>• Projects core to long-term interests |
| Explanations | • Youth as primary maker, with support in background | • Agentive but supported maker<br>• Rationalization of project decisions | • Engaged, collaborative maker<br>• Longer personal narratives – a maker 'story'<br>• How *you* can use or customize the idea |
| | • What and how: what it does, project components, making processes related to the project, how it works | | |

Figure 2.4 Frames of Involvement to a Community (Dixon & Martin, 2014)

According to Herro et al. (2021), makerspaces are interest-based learning communities where the members exhibit a similar approach while problem-solving or achievement of a task. The openness and flexibility of makerspaces enable both asking and offering help among the individuals in the community. Therefore, makers feel the social support and become more engaged in the social structure.

In order to enlarge the makerspaces to a wider community, Taylor et al. (2016) point out the accessibility and openness of the makerspaces. Workshops or other events held on the makerspaces are a common way of integrating the public into making activities. Moreover, the visibility of the makerspaces also catches the attention of individuals who have a tendency and curiosity to the act of making.

Another point of view that relates participation to the community is the importance of "leisure" as described by Vettesse and Anastasiadou (2018). They claim that making activities carried around leisure strengthens the social links among makers.

#### 2.2.3.3.2 Sense of Belonging

McMillan and Chavis (1986) define the sense of belonging to a community with four phenomena; membership, shared understanding, having an influence area, and meeting the needs. Membership raises the feeling of involvement in a community that works for a collective goal. Exploring the projects carried out in the community and the collective aims, one can adopt being a part of that community. Shared understanding is the output of shared experiences of the members, and they tend to interact in order to establish relations with these experiences. This common ground assists members to approach other professionals in the community. Having an influence area is both having a voice in the community and having influenced by the community. Members feel that they put forward their ideas without any concern. Lastly, meeting the needs in the community enhances the sense of belonging with the interchange of both physical resources and knowledge of other community members. In this way, individuals position the community as a valuable source (Roldan et al., 2018).

Similar to various activities carried out in space, makerspaces have various goals motivating makers to engage in the community which improve their sense of belonging. Besides economic and educational goals, makerspaces also serve local needs (Taylor et al., 2016). As a technology technology-oriented movement, makers also provide solutions for educational, environmental or social welfare. Individuals who have environmental concerns, find and share solutions such as solar systems, or waste management within the community (Nascimento & Polvora, 2018).

Makerspaces also provide facilities and environments to potential makers to develop new skills to engage in fabrication. Involving in a productive community empowers discriminated people in society. Thus, individuals who have difficulties while socializing such as disabled people or substance users, find a medium to establish personal connections and integrate into public life (Taylor et al., 2016).

#### 2.2.3.3.3 Community of Practice

Pettersen et al. (2019) define makerspace as Community of Practice (CoP) due to its provided common ground that people share their knowledge and experiences. The learning process is carried through making while socializing in the space. In the community, makers are open to share their knowledge and support each other while making objects. To clarify collaborative action through socializing, Levy (1999) describes ways of forming connections among people with the emergence of the digital world. He introduces two concepts; collective intelligence and cyberculture.

Traditionally, knowledge was stored in two ways; in libraries or in individual's minds. Scholars and libraries were the sources of knowledge, and in order to maintain the knowledge transfer, face-to-face communication and the use of libraries were essential. To achieve collective intelligence, the cohesion of collaborative work and databases is necessary. This cohesion is dependent on the interaction level of human and non-human factors. The familiarity between individuals and their familiarity with the tools, software, and surrounding elements enhance the intelligence of the team. In order to form collective intelligence, individuals should know themselves, their team members, and their surroundings (Levy, 1999). While explaining the learning community, Adams (2006) defines social constructivism as the creation of knowledge via social interaction, perception and understanding since the creation of knowledge is directly related to the social environment. Taricani (2021) states that social construction enables making in groups with the constructed interaction and discussion environment.

Levy (1999) also defines cyberculture as a new type of interaction existing in the emergent digital world. Nascimento and Polvora (2016) express the online community that is enabled in the cyberculture with two phenomena: openness and sharing. Apart from physical settings, maker culture provides online platforms to interchange ideas and help each other to enable every maker to achieve interactive making. Through online platforms, the act of making is reaching out to other individuals or communities. Online networks that exhibit making experiences of makers connect others around co-constructed learning and sharing ecology where diverse methods and mindsets integrate (Peppler et al., 2013). To give an example, online platforms such as Instructables, Thingiverse or Ardunio contribute to the making of both digital and physical products. These platforms enable makers to move from passive consumers to active producers with the connected knowledge of individual makers or their communities (Artut, 2018). Open sharing allows an incremental process that is fed from all makers. While there are part libraries created for 3D models of 3D printable items, makers can develop their own designs and share them on online platforms. Also, hardware platforms like Ardunio enable users to write their own codes and share them with the online community (Camburn et al., 2015).

## 2.3 Summary

Existing collaboration literature emphasizes that the complexity of design problems require diverse design-related disciplines to work on common ground and varying frameworks of collaboration are introduced: multidisciplinary, interdisciplinary, cross-disciplinary, and transdisciplinary (Arias et al., 2000; Barron, 2000; Dykes, Rodgers & Smyth, 2009). Extensive research has been carried out regarding collaborative activity in business-oriented working environments within their organizational, spatial, and social characteristics. Collaboration literature is more focused on knowledge management and decision-making in organizations. Also, how governance and openness of the organization affect the interaction within the community is studied in the literature (Salonen, 2012). Moreover, space as a medium to interact with its element is being studied and emergent coworking ecosystems are introduced (Capdevila, 2017; Mitev et al., 2019). Considering social characteristics, terms of collaborative tie strength, shared value, and common ground are introduced (Barron, 2000; Chaurasia et al., 2020; Cumming & Kiesler, 2008).

In the second half of the literature review, studies related to the Maker Movement are presented extensively. Starting with the definitions of making; makers, Maker Movement, their mindset, and makerspaces are described with the existing literature. Then, the disciplinarity in makerspaces is argued. After that, extensive research has been carried out regarding collaborative activity in makerspaces within their organizational, spatial and social characteristics. Maker literature discusses the learning environment and participation within the organizational context. Dougherty (2016) describes the pyramid of participation while introducing the levels of hierarchy in maker communities. There are also different definitions of levels as space-makers and participants (Davee et al., 2015). Byrne and Davidson (2015) claim that making enables the dissemination of knowledge and changes hierarchical order.  It is also stated that learning in makerspaces occurs with the practice-based perspective through experimentation, tinkering, and questioning (Halverson & Sheridan, 2014; Wardrip et al., 2015). Considering the spatial characteristics of makerspaces, these places have high-tech tools (i.e. 3D printers, laser cutters, CNC routers, and 3D scanners) and low-tech tools. These tools enhance collaborative learning with their accessibility, mobility, and flexibility (Anderson, 2012; Keune et al., 2015). Also, makerspaces are seen as a third-place that stands between home and work, so that learning and working occur informally. Lastly, the social characteristics of makerspaces given in the literature are presented. Taylor et al. (2016) describe these places as *'hubs of community'* where people socialize while working or learning. It is emphasized that people in these areas are like-minded in perspective and show variety in socio-economic backgrounds, ethnicities, genders, and disabilities (Riley et al., 2017; Taylor et al., 2016). Moreover, the sense of belonging to the community and motivations to participate are discussed in the literature (Taylor et al., 2016). Within the practice-oriented environment of the makerspaces, they are also defined as Community of Practice (COP) who share and learn together.

# CHAPTER 3

# METHODOLOGY

The aim of this study is to understand the interactions between individuals from different disciplines while they are working on a common collaborative design project in the makerspace context. Makerspaces are specific working settings for the research to understand the collaboration concept with the emergent digital world and shared economy. In order to understand the collaboration environment in makerspaces, it is required to understand the organizational, spatial, and social elements of the makerspaces to define the interaction among participants throughout the collaborative design process.

In this chapter, the research methodology adopted throughout the study is described. Firstly, the cases investigated in the scope of this study are introduced and their selection process is defined. Considering the research context, a selection of applicable research methods is presented. After that, the sampling strategy used in the research is explained. Following that, adopted techniques through the data collection and analysis are presented considering the context of the research responding to research questions.

## 3.1 Research Approach

This study aims to understand the perspectives and experiences of the makerspace participants through a qualitative approach used in data collection and analysis. Denzin and Lincoln (2011) define qualitative research as a way to approach natural settings in order to deduce meanings from interviews, recordings, or field notes from the perspective of a researcher. Those questions reveal the interaction processes of individuals to get personal, cultural, and historical experiences without any intervention by researchers.

In a constructivist approach, the researcher's data interpretation and foundation of a pattern are maintained through the research process (Creswell & Creswell, 2017). Flick (2004), illustrates the constructivist approach with a circular pattern (Figure 3.1). According to Flick, the world of experiences takes place in events and activities carried on in natural and social contexts. Then, individuals in this world of experience adopt the concept and knowledge. After that, researchers interpret these experiences and attribute meanings to understand the world of experience.

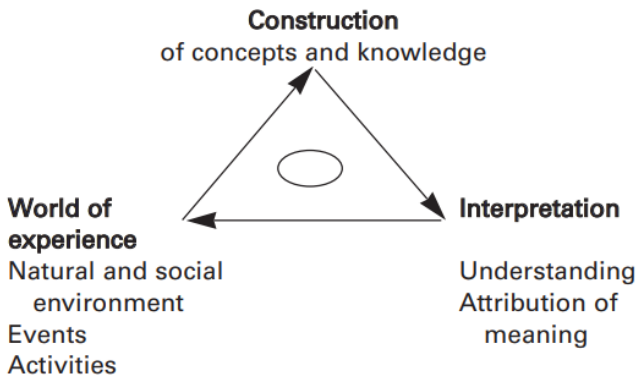



Figure 3.1 Iterative Use of Construction and Interpretation to Define World of Experience (Flick, 2004)

In qualitative methods, there are different strategies to collect data such as ethnographies, case studies, phenomenological research, and narrative research. Establishing relations and discovering meaningful patterns is possible with getting involved with the subjects extensively (Moustakas, 1994). In the scope of this research, it is aimed to understand the experiences of the participants through interviews. Interview as a qualitative data collection method engages participants and researchers in a conversation focused on research questions (Merriam, 2015).

Participant observation aims to capture individuals' behaviours, reactions and interactions to perspective and perceptions (Saldana, 2011). Mapping the relation between members of the community within the space and their interaction with space may illustrate how the collaboration occurs.

Unfortunately, due to Covid-19 Pandemic, using observation techniques in the scope of this research was canceled due to health and safety concerns, because these spaces are enclosed areas with lots of people. During interviews, some of the interviewees made an online tour to explain the space and its usage. Also, photographs and videos uploaded on the websites of the makerspaces are examined to gather insights about them.

## 3.2 Data Collection

In this section, the participants of the study and the data collection technique will be presented. Firstly, the sampling strategy while determining the participants of the study and the process of making contact with them are explained. Then, the data collection technique, i.e. semi-structured interviews, is explained, followed by the interview questions and procedure.

### 3.2.1 Sampling

Collecting data from the entire population which corresponds to the research interest is not feasible. In order to reach a general opinion of the population, a sample of this group should be selected. The basis of selecting this sample is to ensure that the selected group is the representation of the researcher's intended target (Brewerton and Millward, 2001). Sampling strategies can be divided mainly into two categories; random/probability sampling and non-random/probability sampling. Random/probability sampling is a statistical approach to have a general opinion regarding a research question out of a small number of people. Sample elements have the same probability of selection and selection of each element does not depend on or affect the other one (Kumar, 2018). Ritchie and Lewis (2003) state that probability sampling is not applicable to qualitative research studies.

Non-random/probability sampling is mostly used in qualitative research. The selection of the sample is independent of the statistical representation; it is more based on the characteristics of the population. Therefore, it is possible to make a comprehensive study with a small group (Ritchie and Lewis, 2003). Brewerton and Millward (2001) make a classification of four different non-probability sampling strategies; purposive sampling, quota sampling, convenience sampling and snowball sampling.

For sampling, the goal was to reach out to members of makerspaces who are carrying out collaborative design projects. For this reason, makerspace environments are taken as the focus of this research. The sampling methodology applied is *purposive sampling*, since the researcher aims to get the best information from some specific people. In purposive sampling, the researcher assesses the best possible interviewees who provide answers to the research questions (Kumar, 2018). These people are chosen according to researchers' judgement and are more likely to share their objective thoughts and experiences. While selecting the participants, it is aimed to conduct interviews with both users of the makerspaces and facilitators of that service. Makerspace users are defined as regular participants of the space who are involved in making activities. Service facilitators are responsible for the makerspaces' workshop, meeting, and administrative acts. The participants of this study come from different disciplinary backgrounds.

Although purposive sampling is quite effective for gathering in-depth knowledge, it is difficult to reach many people. Due to the Covid-19 pandemic, it was not possible to observe the participants in their coworking environment and choose the participants using purposive sampling. Therefore, *snowball sampling* is also used to reach more participants. Kumar (2018) defines snowball sampling as the selection of participants through networks. It is useful when the researcher has limited contacts in the community. Required information about the participants is taken from the facilitators of the organizations or from individuals who have a strong network in the maker community. This strategy gets the researcher involved in the community faster and enables him to reach more people. Since the maker organizations are socially connected and not so crowded, the use of this technique was implementable.

Before giving the detailed sampling strategy applied in research, different research cases investigated through this study will be introduced. While introducing these makerspaces, the sampling strategy adapted for these cases will also be presented. In the scope of this research, maker communities from different fields of applications such as academic makerspaces (universities), non-profit maker organizations and social maker enterprises who have makerspaces will be investigated. Throughout this research, four maker communities were investigated. Research cases are selected from different cities in Turkey. While reaching these makerspaces, it was important to consider their willingness to partake in academic research. In order to reach people from these organizations, I contacted their directors or responsible persons and provided information about the research. Upon their approval for the research, further communication is done with the volunteer participants. The names of these communities and participants are kept anonymous per their requests and categorized in Table 3.1 with their descriptive characteristics.

Table 3.1 List of Makerspaces and their Descriptive Characteristics

| Case No | Field of Application | Use of Space | Location |
|---|---|---|---|
| Case 1 | Academic Makerspace | Dedicated | İstanbul |
| Case 2 | Voluntary Foundation | Distributed | Ankara |
| Case 3 | Social Enterprise | Distributed | İstanbul |
| Case 4 | Social Enterprise | Dedicated | İstanbul |

Case 1 is a collaboration center that enables making activities and technology-based education on a university campus. It is a shared area by university students, academicians and other members who are willing to take part in maker projects. Since the makerspace contains lots of facilities within, there are responsible people in the space too. They have roles like coordinators, machine operators, and event or workshop facilitators. Makerspace participants have the opportunity to carry out their individual or group projects in a shared environment. In the makerspace, there are open workshop sessions about technology, design, and production to integrate university members into making and introduce the space available for production on the campus. Also, project calls are announced to enable the interaction of university members to raise awareness about the Maker Movement. Thus, both the university environment and makerspace enable the formation of collaborative settings with the effort of facilitators and members. The selection of Case 1 was done with *purposive sampling* since the researcher took the information about the makerspace and their activities through online platforms and evaluated it as a suitable research group.

For Case 1, the director of the makerspace was the contact person. The researcher contacted the director of the makerspace via mail. A preliminary meeting was held with the director to explain the aim and scope of the research. Since the makerspace held their activities in a university institution, there was a consent process. After the approval of the research, the scheduling of the interviews was asked from the director. Both *purposive sampling* and *snowball sampling* techniques were used while selecting participants. Since the preliminary meeting provided initial thoughts about the structure, the researcher asked to conduct interviews with two makerspace facilitators. Then, an interview with the director was conducted. After these interviews, in order to increase sample size, *the snowball technique* was used with the help of the director of the makerspace. These 3 interviews were planned through e-mail correspondence. First, the users of the makerspace were invited for the research through public e-mail. According to the reply of the makerspace users, three interviews were scheduled and the diversity of disciplinary backgrounds was achieved: electric-electronics engineering, mechanical engineering, and industrial design.

Another research group of the study, Case 2, is a voluntary foundation located in Ankara that aims to design and produce prostheses for kids who experienced the loss of a limb. Within the structure of the community, there are teams that respond to the calls from the kids in need. Through online platforms and networks of members, kids and their families get in contact with the community members. The feasibility of the prosthesis is discussed primarily in the community, and accordingly, the design process starts. There are volunteers participating both physically and online, and these volunteers vary in terms of their discipline and expertise. Members of the community are mostly composed of professionals and university students who are willing to take a voluntary mission in the organization. Through the design process, teams including members from different disciplines are found to come up with comprehensive end-products. The selection of Case 2 was done with *purposive sampling* since the researcher already had information about the community and its convenience to the research.

In order to reach participants for Case 2, the facilitator of the organization informed the possible participants of the study and contact information of these participants were provided to the researcher. The researcher reached them through Whatsapp, and interviews were conducted with four participants. Since the researcher did not select participants and the selection was done with the guidance of the organization's authorized person, *snowball sampling* was used for this case. Selected participants were the regular attendees of the community having nearly 2 years of background. Therefore, it was possible to gather their in-depth experiences in the makerspace. The diversity of the disciplinary backgrounds was achieved: electrical-electronics engineering, mechanical engineering, business management, and industrial design engineering.

Case 3 is a voluntary foundation located in Istanbul that aims to generate projects for local issues. They position repairing, making and sharing at the core of the community. Local problems are announced and members are called to participate in the projects. Community members possess varying disciplinary knowledge and levels of expertise. Activities are carried out in various places that provide required facilities.

Case 4 is a social enterprise that aims to make knowledge accessible in the community with shared experiences. There are facilitators and members of the space. Facilitators drive the learning environment by matching the experts with the members who have a desire to learn. In terms of social and academic background, there is a diverse range of members. While facilitators are low in numbers, there are large numbers of participants that are in contact with the community. Activities are carried out in a makerspace and online platforms.

For Case 3 and 4, *snowball sampling* was used again in order to reach the facilitators of these organizations. With the help of a contact person in the maker community, participants agreed to partake in the research and online interviews were scheduled through emails.

The list of participants and their information are provided in Table 3.2.

Table 3.2 List of Participants and their Information: Involved Case, Role and Discipline

| **Participant Number** | **Involved Case** | **Role** | **Discipline** |
|---|---|---|---|
| Participant 1 | Case 2 | Member | Electrical and Electronics Engineering |
| Participant 2 | Case 2 | Member | Industrial Design Engineering |
| Participant 3 | Case 2 | Member | Business Management |
| Participant 4 | Case 2 | Member | Mechanical Engineering |
| Participant 5 | Case 1 | Employee | Electrical and Electronics Engineering |
| Participant 6 | Case 1 | Employee | Mechanical Engineering |
| Participant 7 | Case 1 | Manager | Industrial Design |
| Participant 8 | Case 1 | Member | Electrical and Electronics Engineering |
| Participant 9 | Case 4 | Founder | Mechanical Engineering |
| Participant 10 | Case 3 | Founder | Mechanical Engineering |
| Participant 11 | Case 1 | Member | Mechanical Engineering |
| Participant 12 | Case 1 | Part-time Employee | Industrial Design |

### 3.2.2 Data Collection Techniques

In this research, semi-structured interviews were used as the data collection method. Interviews were conducted with the participants who can provide a deep understanding of the collaboration characteristics of makerspaces through the organizational, spatial, and social aspects. It was difficult to gather data about the spatial characteristics of makerspaces due to Covid-19 Pandemic. In order to understand the spatial elements and their use, alternative methods and techniques were explored. One of the service design methods, *desktop walkthrough* was conducted initially. The researcher prepared a layout that ask interviewees to visualize their usage of the area by mapping the space. While mapping the space, interviewees were asked to define interaction points, their actions, thoughts, feeling, critics and suggestions about the related experience. These actions are probed with a *narrative approach* throughout the whole experience in space. However, this methodology could not be implemented, since interviewees were not willing to fill the layout template. Therefore, the researcher decided to get the required knowledge about space throughout the interview questions. Interviewees were asked to share their one day in the space with narrating. They defined the interaction points, their activities in the space, the person they make contact with, equipment they use, or their favourite spots in the space with a narrative language. Moreover, the researcher reach photos and videos of the space on their website to visualize the space. Also one of the interviewees made an online tour in the space to introduce the layout, facilities and use scenario of space. Firstly, the use of semi-structured interviews is explained corresponding to research. Then, interview questions and the process of conducting interviews are given.

#### 3.2.2.1 Semi-Structured Interviews

deMarrais and Lapan (2003) state that an interview is a comprehensive discussion concentrated on the research questions. This discussion includes the thoughts, opinions, perspectives, or descriptions of the specific cases experienced by the interviewee. Interviewing is an effective way of gathering data since it provides past experiences of the interviewee (Merriam, 2015, p. 88).

There are different types of interviews that can be classified considering their structures. This classification starts from highly structured and continues with semi-structured and unstructured/informal interviews while the discussion environment is enhanced. Highly structured interviews go through predetermined questions with a predetermined order. It is described as an oral form of a written survey. Secondly, semi-structured interviews are done with less structured questions which have flexibility in wording and order. Specific data expected from the interviewee is gathered with the help of these questions. Lastly, unstructured interviews are more like a discussion with open-ended questions. The main goal is to learn about a phenomenon and gather insight related to the case in order to redefine questions (Merriam, 2015, p. 89). In this research, semi-structured interviews are preferred, and the researcher aimed to facilitate a conversation with the interviewee directing *how* and *why* questions to gather in-depth knowledge (Adams, 2015).

Roth and Kleiner (1998) state that knowledge is placed among interactions, artefacts, and experiences of the people. Revealing this information with the combined viewpoint of the participants is possible with the *learning from history* method. With a constructivist approach, these jointly told stories provide involvement of the researcher to the case and enable making a comprehensive interpretation. Interview questions are directed to the participants of the research through asking the stories in order to gather deeper insights related to cases (Lloyd, 2000).

#### 3.2.2.2 Interview Questions

Interviews are performed using an interview guideline to direct the interviewee through sets of questions. There are five main sections of interview questions and sub-questions are prepared to make a deeper discussion (Appendix B). Interviews start with warming-up questions to get to know the interviewee. Interviewees mention their interest in the maker culture and involvement process to the makerspace while defining motivations. After getting to know the interviewee, the second set of questions are asked over their project process to understand collaborative action and the progress followed in the organizations. The third set of questions are related to the makerspace environment, its usage practice, and the effect of the space on the collaboration. The fourth set of questions is covering the social links and community behaviour in the maker organizations. Lastly, interviewees were asked to make a comparison of interdisciplinary collaboration experienced in makerspaces with their previous experiences in business-oriented working spaces.

Apart from the predetermined questions, I tried to ask further questions. In order to reveal opinions and stories behind the answers, it is required to engage interviewees to share more about the topic. With the help of follow-up questions, interviewees feel comfortable and extend the scope of the conversation (Scott & Garner, 2012). To make interviewees’ contributions easier, interview questions were asked through exemplifications. Bailey and Tilley (2002) state that interviewees intend to tell stories that follow a particular flow including layered meanings constructed by interviewees. Rather than giving the *truth* about a topic, they make *meanings* through stories. While asking about the project progress in the community, interviewees were asked to answer using ongoing projects, or past experiences. Furthermore, while describing the space and its use, interviewees were asked to use role-playing to illustrate the process. Therefore, it became easy for both interviewees to express themselves and researchers to understand the environment.

#### 3.2.2.3 Conducting Interviews

At the beginning of the interviews, a written consent form is was given to the participants, outlining the aim and scope of the research. Also, interviewees were informed about how and where the collected data will be stored and used. In the provided consent form in Appendix A, it is stated that participation in the research is voluntary and interviewees have the right to leave the research anytime without presenting any reason. Throughout the interviews, audio and visual recording were collected and they were transcribed and anonymized. After oral consents were taken from the interviewees, I introduced myself and the research aims. Although they had initial thoughts about the research, it was important to make a clear explanation.

Due to Covid-19 pandemic, interviews are done through online platforms, such as Zoom, and Skype. Appropriate places for the video calls are chosen to avoid any interruption or sound problems during the interviews. Before starting the interviews, consent for the recording is asked from the interviewee, and approval of the participant is taken orally at the beginning of the records. Since online media communications provide audio and video record options, they are quite beneficial to capture the gestures and tones. Apart from these tools, note-taking is done throughout interviews in order to highlight some specific reflections and generate in-depth questions.

As the interviews were conducted, I became more experienced in directing questions and managing the process. When I felt the conversation driftıng away, I intervene by directing to the next question with a transition. For example, one of the interviewees was talking about his individual projects in the makerspace. Responding to that situation, I asked him to give examples of group projects that he was involved in. Also, there were interviewees who were not willing to speak more. Interviews carried out with these people required more short sub-questions they could answer easily. Also, illustration and exemplification were asked to make them comfortable. For instance, questions related to spatial usage of the space were asked in walk-through sessions supported with storytelling.

Interviews were planned for about 45 minutes long and this was declared to the interviewees. The interviews took about one hour and interviewees were comfortable with the timing. Interviewees were willing to contribute independently of time. One of the interviews took 3 hours in total, consisting of two different sessions since the interviewee had things to share.

### 3.3 Data Analysis

After data collection with the semi-structured interviews were completed, I started to analyze the gathered data. There were six main steps while conducting the data analysis (Figure 3.2). First of all, I started the verbatim transcription of the interviews to make an extensive overview of the data. After that, using the template analysis method, a thematic analysis of the data was performed. At the beginning of the process of template analysis, the initial template was constructed. Then, using the codes that were defined in the initial template, novel codes were derived from the transcripts. This first cycle of coding revealed new codes to revise the template. After the second and the third cycle, codes were redefined iteratively. Thus, it was possible to organize relevant themes to extract the analysis outline. Lastly, quotations that support the codes in the analysis outline were translated into English (King 2004).

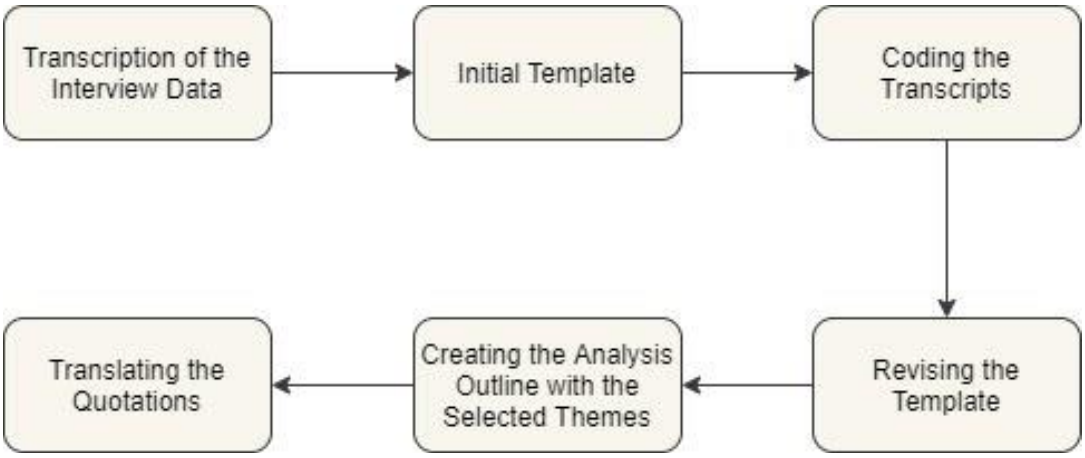



Figure 3.2 Data Analysis Process

### 3.3.1 Transcribing the Interview Data

Transcription of the data from audio to written text is a difficult process. In order to improve the process, different methodologies were used throughout this phase. While transcribing the data, the voice typing tool of the Google Documents was used. After that, editing of the texts was done and mistyped words were corrected. Since the program uses its data source to make an inference, Google Documents was not successful enough. Overcoming this issue, there are different online tools specialized in voice typing. Speechnote is one of them and it gives more accurate wordings with less effort in editing. In order to make transcriptions faster, there is a need for using audio control programs. I used my phone with headphones to listen to recordings and my laptop to use voice typing. Play/pause control and fast rewind/forward is easier on the phone without switching between tabs.

While making transcriptions, I paid attention to write all the things in the records without interpretation. Also, interviewees' pauses, gestures, and reactions were noted. While transcribing the data these notes were used to remember the context.

### 3.3.2 Template Analysis Method

In the template analysis method, templates are used to organize themes and analyze the data. The distinctive feature of template analysis is that researchers generate a list of codes that represent themes in the transcribed data. These primary codes become the initial template for the analysis. Then, researchers revise this template after reading and interpreting the transcripts. Codes in template analysis are in hierarchical order, which means related codes are grouped under a main theme which is the high-order code (King, 2004).

Data analysis techniques remain in between openness and the structured processes. While openness causes us to deal with chaotic and irrelevant data, structure restrains the researchers. The template analysis method introduces a balanced analysis process. Since template analysis provides a starting point for coding the entire transcripts, it makes the process of data analysis easy and quick. Also, with the flexibility of the method, researchers can change the groups and hierarchical orders of codes in templates with more iterations (King, 2004).

#### 3.3.2.1 Creating Initial Template

Initial templates are prepared to analyze the transcribed data with predefined codes. It is important to determine the extent of the initial template since too many predefined codes mislead the analysis. On the other hand, too few predefined codes may cause the researcher to get lost in the data. As a starting point for the initial template, interview questions can be a guideline. While main sets of questions can be used to define high-order codes, sub-questions can be used to define low-order codes (King, 2004). In this research, high order codes are generated through main questions and defined subgroups. While there are five main sets of questions, nine high-order codes were defined. These codes are given as follow:

1. Attendance to the community
2. Organizational structure
3. Team dynamics
4. Learning practices
5. Collaborative working through the design process
6. Makerspace as a collaboration provider
7. Maker community
8. Comparison of makerspaces with business-oriented workspaces
9. Effect of maker culture into work-life

Since transcription processes enable getting familiar with the data, low-order codes are determined from these readings and the notes taken during interviews.

#### 3.3.2.2 Coding the Transcripts

Coding was carried out manually using the hard copies of the transcribed data. In order to start the coding process, transcribed interviews were printed to work practically on paper. Layouts of the transcripts were arranged to have space between rows and both sides of the page. To follow the codes easily, rows were given numbers. Before starting the coding, the initial template with the hierarchical order was prepared too. King (2004) emphasizes the differentiating aspects of the coding process in template analysis as hierarchical coding and parallel coding. In hierarchical coding, researchers create codes in a structured order. While high-order codes enable researchers to gain general insight about the interviews, low-order codes provide detailed inferences from the transcript. Also, in template analysis, parallel coding could be carried out by giving two or more codes for the same segment. Through the coding process, both predefined codes in the initial template were used and new codes were defined along with each statement. Some of the codes given in the initial template were not encountered in the transcribed data. Therefore, these codes were removed, and new codes derived from the analysis were added to revised templates. Coding examples applied to transcribed data are given in Appendix D.

#### 3.3.2.3 Revising the Template

It is possible to revise the template with the provided flexibility of the template analysis method. Alterations that can be applied while revising the initial templates are given as insertion and deletion, changing scope, and changing high-order classifications. These modifications could be applied to the initial template in case of revealed insufficiency (King, 2004).

**Insertion and Deletion:** Codes defined in the initial template may be removed since there is no valuable argument while constructing the template. Also, it is possible to define new codes that are not available in the initial template. Therefore, while revising the template, researchers can both insert new codes or delete unnecessary ones.

**Changing Scope:** Codes that are defined as low-order codes may change their scope through the revising process. When a code becomes prominent, researchers revise its hierarchical order to address its importance.

**Changing Higher-Order Classification:** Codes that are located under a higher-order code could be shifted to another higher-order code through the revising process.

Revised templates orient the researchers to construct the final template of the research analysis (King, 2004). Layouts of the template analysis method with iterations are given in Appendix E. Main themes and supporting low-order codes in a hierarchical order constitute the analysis section of the study.

### 3.3.3 Translating the Quotations

All the interviewees who participated in the study were Turkish. Therefore, interviews were conducted in Turkish since both participants and researcher are fluent. After the analysis is done, selected quotations that support the analysis arguments are translated into English. While translating, the use of correct words and understandability is considered. Also, the names given in the quotations were anonymized.

# CHAPTER 4

# RESULTS

In the previous chapter, the methodology used in data collection and the approach used through analysis is explained in detail. This chapter emphasizes the analysis of the gathered data from interviews conducted with the participants who are both members and facilitators of the space. First of all, the involvement process of the makers to the community is described in order to understand the personalities, expectations, and organizational effort to enlarge the community. Secondly, collaboration characteristic in the makerspaces is analyzed considering organizational, spatial and social aspects of collaboration. Lastly, the drivers of the collaboration are analyzed through a comparative approach among differentiating structures of goal-driven and place-driven makerspaces. In addition to these differences in drivers, participants' previous experiences are also compared with their experiences in makerspaces to reveal dynamics of collaboration through the previous experiences of the participants.

## 4.1 Involving a Collaborative Community: Makerspaces

Makers are individuals who are participating in making activities. Making activities in this context can vary from knitting to making skateboards. Although these activities are carried out individually, I approach the makerspaces from a collaborative frame. Makerspaces are open working places for people who have the eagerness to make. To understand the collaboration environment in makerspaces, it is required to understand their motivation while attending these environments.

Maker activities mentioned in interviews mostly start with personal interests as defined hobbies. These individuals use their own production facilities to make products as individual makers. While one of them is interested in resin molding of flowers, another one produces electronic boards in their personal space. In order to lead this movement to a collaborative frame, there is a need for initiatives that spread this culture. Makerspaces investigated through this study are located in the universities or independent social enterprises in local areas. While they are mostly used by students, other stakeholders of the university and local people participate in the area too. Since the desire to produce does not belong to a demographic portion, it is measured with the characteristics which define makers. As makerspaces are presenting an open-to-use area, the involvement of the makers in the area depends on both participants' characters and the makerspace facilitators' approach. Through analysis, most of the interviewees emphasize their previous experiences and their interest in being involved in production. Also, from the perspective of makerspace facilitators, they state that they make an effort to enlarge the community. Participating in the space has become appealing with the encouraging environment that makerspace facilitators are trying to build.

### 4.1.1 Productive Characters

Makerspaces are new working areas that inspire production with their facilities and environment that spreads maker culture. Participants of the research are mainly from engineering, design, architecture fields. Their involvement in makerspace is analyzed through their previous making activities and meeting process with the space. In the following section, it will be explained how the diversity of makers' interest areas affect the formation of collaborative spaces. Also, it is mentioned their search for a space to carry out their production activities.

#### 4.1.1.1 Multifaceted Interest Areas

Participants of the research can be identified as people who seek different fields to improve themselves. Their seeking for improving themselves is not focused on a specific area. Both in their professional education or their interest areas explain their curiosity. Although they have expertise in a field, their effort to diversify their career can be observed clearly. Some of the interviewees who continue their education are having minor programs in universities. Among the students, there is an obvious transition between the fields of engineering, management, design, and architecture. While one of the participants studies mechanical engineering, he is also trying to learn management. For example, an industrial designer completed a minor program in architecture. Apart from their education, their personal interest areas lead them to explore new fields. For example, having an interest in making sound systems guide one of the mechanical engineer participants to electrical and electronics fields. These transitions make the interaction among makers possible to reach knowledge. This exploration enables them to collaborate with people from different fields of expertise. Makerspaces are good instances of common ground which enhance the collaboration of various disciplines.

Most of the interviewees have backgrounds that involve various attempts to widen their knowledge area. When they move to a new place or get into a university, they seek a place to carry out their productive activities. One of the participants of the study points out his search for a new area to make:

> I was involved in projects related to robotics, mechanics, and design since my high school, even secondary school years. When I first entered the university, I found myself on a quest. *Participant 8, Member, Mechanical Engineering*

While they were intended to maintain individual-making activities in their early occupations, it became a search for a community that had similar perspectives. Individuals who are situated in various areas tend to find a place that gathers diversity together. They look for alternative paths to improve themselves. A collaborative environment in the makerspace is seen as a supporting mechanism for the people who go after their multifaceted productivity.

Regarding their search for a collaborative environment, it is seen that the diversified field of interest in space comes true with multifaceted personalities. One of the interviewees defines being a maker as doing studies in many areas rather than focusing on a field.

> My thesis study is on communication, but if you ask what you are doing, for now, I am doing studies on software. Also, machine learning and deep learning. Actually, being a maker requires this. You should do studies in many fields rather than just one field. *Participant 5, Employee, Electrical and Electronics Engineering*

While makers have multifaceted interest areas, there is a dynamic relationship between these fields in makers' thoughts. These varying areas are gathered up together with the creative vision. Having connected with people who have different expertise initiates their creativity to form interdisciplinary relations. One of the interviewees is explaining how the bridge is formed between different areas with a creative perspective.

> While I am a fan of yoga and art at the same time I think over and read something about data sciences too. I would study coding. While doing some knitting, at a moment I ask myself how can I bring knitting and wearable technology together? *Participant 7, Manager, Industrial Design*

It is seen that makerspaces form an interdisciplinary environment with the makers who are willing to perform their creative activities while benefiting from various fields. Their motivation to involve a space that enables production brings productive personalities together. Diversity in personal interest enables them to integrate their individual perspectives. Therefore, multifaceted makers maintain their diversity by establishing creative collaboration.

#### 4.1.1.2 Productive Environment Seeking

Makerspaces as a new form of workplace centralizes the production differently from the other working environments. Having a fabricated or handcrafted product is an important motivation for a maker. Therefore, their involvement process in a makerspace depends on the facilities and the environment which enable production.

Productivity in the space has an influence on developments in both personal and social perspectives.

Interviewees who attend makerspaces for personal improvement are relating makerspace with education or hobby areas. Considering the educational improvement, one of the interviewees from industrial design describes his involvement aiming to meet her prototyping needs for school projects. Another interviewee thinks that Case 2 is a preparation for her future career path, the biomedical design field, in a practical way.  Besides, some of the participants describe their motivation as being willing to be included in a productive environment. Supporting this idea, one of the interviewees makes a comparison while explaining her involvement in the area. The interviewee emphasizes the deficiency of start-ups while transforming their ideas into a product.

> It was like this. I worked with startups a lot. They are bringing their jobs to a point and then before coming onto the market, the project makes a fall. There is a downfall at that point. As a designer who is accustomed to produce and see the production, it becomes an unpleasant situation. And I said to myself, I should be in a place where production happens otherwise I cannot. *Participant 7, Manager, Industrial Design*

As stated in the above quotation, being included in production is a strong motivation. Makerspaces enable their members to experience making while converting their ideas into tangible means. Their background that includes making guide them to involve in a productive space. Listed motivations to use the area have similarities while positioning makerspace as a facility that enables the practice of making.

The product that the maker establishes a relationship with is describing his passion while involving a makerspace. Some of the interviewees share their trials of production before joining the community. There are various products that they have already produced such as resin necklaces or baby dolls. One of the interviewees tells about his first days in the university. He has an interest in making electronic boards in high school, and to continue his activities in the university, he is looking for an area. These items create a means to communicate and demonstrate his intent.

> When I was coming to space, there was a project in my mind. Most of the people who attend here have their projects in their minds. I ask whether I can use the area or not. I was always carrying my printed circuit boards with myself. There was a problem with the PCB, and I was looking for a laboratory to work. *Participant 8, Member, Mechanical Engineering*

As the interviewee stated above, participants of the space already have their projects to carry out. Using the products that they have created, participants meet with the space and show their motivation and expectation to the facilitators. They show that their individual productivity needs a space that facilitates their needs. Also, makerspace is an environment that creates means to communicate with outer space too. A physical product created by a maker becomes a promotion tool when they interact with somebody who tends to produce. One of the interviewees point out the reflections of the products in the social environment as an interaction enabler:

> We see the reflections outside of the makerspace. For example, one of his/her friends shows the product which he/she produces in the makerspace. After that, that person comes to the makerspace to ask whether he/she can produce the same product too. They ask whether there will be a second workshop or not. They are talking with each other outside. We do not have comprehensive knowledge about the conversations, but we see the reflections here. *Participant 7, Manager, Industrial Design*

It is seen that the social environment which the makerspace represents is appealing for the people who prioritize having a social identity. Means produced by the makers create an interaction outside of the makerspace but this interaction leads to motivation to involve that social group. From this point of view, the curiosity of making can be related to social concerns too. Knowing that the social environment makerspace provides, it is also valued to create social impact benefitting from the maker culture. For example, using the 3D fabrication tools, makers contribute for children who have prostheses. Moreover, it is possible to create an open library for local people using woodworking tools. Makerspaces use these facilities to have an impact on the social environment with the help of community members. One of the participants illustrates his initiative as a social benefit-oriented maker community.

> The 3D printer has incredible repair power. For example, you have a 1980 Mustang, you cannot find a part, but you can repair it with a 3D printer. Can we set up something like a repairer's club where a 3D printer is also integrated? Later, when I got involved in the subject, we started thinking about what we can do together. We try to bring 3D printer technology to the streets and decide to repair the streets by beautifying them, that's how we started. *Participant 10, Founder, Mechanical Engineering*

Knowing the capabilities of recently developed fabrication tools, awareness of the ability to produce expands. While 3D printing can be used for personal needs, using it as a production tool for a social benefit makes the participants a part of the social community. Empowered use of the maker facilities in the context of social benefit becomes a motivation to involve makerspaces.

Makers are in search of a productive environment to carry out their individual projects and to attend social benefit aimed projects. These aims bring makers to a common ground where productivity is prioritized. The motivation of creating tangible means shows that participants of the area have the eagerness to maintain their individual making activities. Their intended use can be described as facility usage and have effects on the surrounding since the means they create become a motivator. For some of the makers, the act of making has more social power than personal use or satisfaction. It is noted that having a social effect on productive actions motivates them to attend to the community too.

#### 4.1.2 Inviting Members by Encouraging them to Use Area

Apart from the maker personality, makerspace organizations and their culture invite individuals who have an eagerness to make. Makerspace organization is governed by a group of people who maintain the activities held on. Makerspace facilitators in this research describe themselves as familiar to the maker community with their high attendance to previous maker activities in Turkey. They usually have previous community experiences in different organizations or they are familiar with the maker network in Turkey. Relations among space-makers and participants of the space are crucial to run a community. Therefore, the management of the organizations is exhibited by space-makers from a sustainable and collective perspective. While they are inviting to space, they emphasize both the production facilities presented and the support for practicing.  Also, it is emphasized by the interviewees, makerspace facilitators give value to their ideas. Adaptation processes of the new makers are accelerated by giving them opportunities to get roles in the community. It is essential for the sustainability of makerspace organizations.

Participants who need specific production facilities while doing their projects explain their involvement by their deficiency of tools or space to produce. While some of them use the area to use 3d printers, others use the space as a place to sandpaper or spray paint. Therefore, the facilities makerspaces provide are important to make the space in demand by the makers and possible entrepreneurs who incubate their ideas.

> It is also very important for the entrepreneur to prototype. At least it did something tangible. Or for you to attract good entrepreneurs, you should say what types of opportunities you have. *Participant 7, Manager, Industrial Design*

Makerspaces supports initiatives that come up with an end product using the provided production facilities. In makerspaces, with the equipped production facilities, prototyping is the dominant design phase. The prototyping phase consists of generating mockups as much as possible to reach an advanced product. Makers have the opportunity to realize their ideas with the rapid production facilities without beware of making mistakes. Therefore, makers are supported by the community to have trials and errors.

> We want them to see the space as a trial court, and cooperate there. I am remarking that and nobody is refusing this so far. It is so important to tell that person, you are not expected to do magnificent work. *Participant 7, Manager, Industrial Design*

There is the idea of learning from the beginning. Whether someone does not know anything or is inexperienced, makerspace provides a supportive environment that cares about your development within the community. Apart from leading countenance to prototype in the environment, most of the interviewees find that there is a supportive environment for their ideas too. Makers are encouraged to share their ideas without any prejudice. It is arising from the understanding that everybody contributes to the community with his creative perspective.

> You come first, you are looking. Can I do anything here? You say, will they let me? But when you come in, that group behaves so sincerely. They value your project. They look at your project as an idea. They don't say this is ridiculous. You feel comfortable and they allow you to be more productive. *Participant 8, Member, Mechanical Engineering*

The involvement process is enhanced with the opportunity given to the new makers. Motivating them to meet the experience of making leads them to join the same set of creative perspectives.

> In general, we explain the works to the students in the workshops. For example, we will glue this to the wall; we explain how to glue it, clean the surface before glueing, what kind of glue we use. Then we say, let's do it! In these modules, giving people these experiences is the thing. Once we go out and look at the public sphere from a different perspective and photograph the points that can be nice for us, we say let's design and produce it if you have an idea. This is actually the biggest interest. Creating this kind of experience is the main thing. After adding that experience, they realize that they are looking at the street differently. *Participant 10, Founder, Mechanical Engineering*

As illustrated in the above discussion, makerspaces enable flexible use centralizing the creative production and give support makers to embrace them. Through giving space to newcomers their involvement in the culture is accelerated. This supportive environment enhances the diverse ideas and profiles to improve the collaborative environment. In the following section, collaboration characteristics in makerspaces will be analyzed with the light of makers' productive characters and the encouraging space elements.

### 4.1.3 Chain of Involvement

While participants of the makerspaces meet with the community, there is a chain of events that makes them integrated into the space gradually. It is a process in which a member who wonders about the community becomes a space-maker who carries out organizational tasks. On the other hand, founders of the research cases also follow a different process while having this role. Since some of the participants are already founders of the maker community, their involvement is initiated with the creative communities that they are in contact with. Their involvement starts with their effort in other making related creative activities like workshops, meetings, or fairs. One of the interviewees, the founder of Case 4, shares how he decided to found the community:

> I realized that things including terms learning, teaching, and making are related to me. I said I had to find a profession like this. I didn't even know the meaning of the word “maker”. I came across the word “maker” after attending an entrepreneurship training. Eric, who is the founder of [a coworking space], came on the third day of entrepreneurship training and introduced himself and [a coworking space]. He introduced it as a maker community, of course. I liked it when I saw him. I said I should come up through the ranks. I was working in [a coworking space] before I founded Case 4. I realized that there was a serious deficiency in practicing maker culture. I decided that this community should be established. *Participant 9, Founder, Mechanical Engineering*

As stated in the above example, there is a process that starts with the effort of the interviewee being in the creative activities. It provides the environment to meet and understand the field that he wants to be included in. Similarly, the community manager of Case 1 also follows a chain of events that make her correlated with the maker communities. She mentions below how her experiences converge her to the field:

> As a designer like me, who is used to producing and seeing production from the beginning, I said I would go somewhere that was production or I wouldn't be able to. I am more interested in technology. Also, I love the training fields and I was creating my own content for workshops. I'm probably one of the most active people in a lot of workshops for about 10 years. In fact, I am a

person who produces and conducts their content by myself in the last 6 years of this. At that time, I was working at the [a makerspace]. Also, I was giving training on these coworking spaces that are increasing especially in certain areas. Actually, that's how I first met the former manager of Case 1 at the Maker meeting. We had a close friendship. Then I started producing external content for them, holding workshops there. After that, I joined the community as a manager. *Participant 7, Manager, Industrial Design*

Since she has abilities in the field of education and an interest in technology, she becomes close with the maker community. It is also seen how people in the creative fields are close to each other with the events, meetings, and workshops. While space-makers experience a process to involve in a maker community, they also prepare the environment for the members inclined to make. When the process they follow is examined, it is seen that there are different stages experienced. While some of the makers take initiatives with a sense of responsibility, some of them are guided by the space-makers to get a role in the community. One of the interviewees explain the stages she experienced while she got involved in the community:

> Getting to know the project I said I wanted to volunteer. After that, there were coordination problems and I felt bad after being delayed for a bit. Then, I took more responsibility. When [two members of the makerspace] saw that I couldn't get support from volunteers, in this case, they gave great support to me. We have been spending too much time together during the project phase and in this way, I met them closely. I adapted more, my motivation increased, I said that I wanted to participate in more cases. When they saw that my motivation was high, they said that if you want to participate in more cases, can you help us in the coordination team, so I started to participate a little more actively in this way in the community. *Participant 3, Member, Business Management*

It is seen that she follows the stages; feeling responsible, putting more effort, having support from the space-makers, increased motivation, and getting a role in the community. This process is more started with individual effort and Participant 3 gained acceptance within the community. Common goals digested by community members ease their involvement process. Also, some interviewees state that members are involved in the organization by the guidance of the other space-makers. It also depends on the individual effort of the members.

> Let's say you are attending one event, Design thinking or 3D Design Training. If you are interested, you want to continue and attend all the other training sessions. Then, we observe and give small tasks to you. You will organize a workshop, and I will help you with the content of the workshop. First, you will show me your draft, then we will talk about it together. Then, we act as if we are holding a workshop. We want to make them integrated into the task to see their possible contribution. *Participant 6, Employee, Mechanical Engineering*

As stated above, it becomes more of a recruitment process that tests the members who have active participation. This kind of involvement is more seen in Case 1 since students in the university work as part-time employees. Their involvement in the space-makers has a direct relation with their curiosity to make and their contribution to the community. Since makerspaces carry out their activities with both facilitators and participants of the organization, it is important to make the community sustainable in terms of its members.

## 4.2 Organizational Dimensions of Collaboration in Makerspaces

In order to understand the collaboration in makerspaces, it is also important to understand the organizational dynamics. Participants of the makerspaces act in an organizational structure, and this structure affects the collaborative action here. Since collective use of the space is studied in this research, members of the area gather together within teams. While space-makers work as a team to conduct activities, participants of the makerspaces also carry out projects together. Therefore, it is necessary to analyze the team dynamics. Besides, there is a process of decision-making where the individuals interact through the projects. That stage of the project shows the hierarchical structure and decision mechanism in the organization. Also, these environments provide an educational facility using its particular tools and mindset. It is also analyzed how learning occurs in the makerspace context.

### 4.2.1 Team Dynamics in Makerspaces

A collaborative environment depends on team dynamics when the people come together for a common goal. While there are projects carried out in teams, there are also workshops or one-to-one interactions in which collaboration can be observed. In makerspaces, the team differs considering its role-sharing motivations, diversity in expertise, and discipline concept. Collaborative attitude in the team is mostly related to the maker characteristics and the culture defined in the previous section.

#### 4.2.1.1 Leaning Oriented Role Sharing

Team forming is a process that includes various aspects considering both expertise and motivations. Although makers have different expertise, projects they are involved in do not ask for a prerequisite. It is stated that necessary knowledge can be gained through lessons and trials. While maker communities run a project, teams are formed with the member's motivations rather than the allocation of tasks. Also, projects or workshops carried out in the makerspaces are sometimes announced by making open calls over social media or printed posters. Therefore, makers' attendance depends on their interest in that specific topic. Since projects conducted in makerspace are voluntary-oriented, their participation in the projects depends mostly on their leanings.

Makerspaces have a diverse range of participants from university students, academicians, and local people. These subgroups are seen under the same roof that represent a community that has the eagerness to learn. Since they are actively participating in the production practices, their inclination to explore new interest fields becomes possible with the maker environments.

Participants of the makerspaces are usually university students who tend to improve themselves in different fields apart from their education area. For example, Participant 10 (Founder, Mechanical Engineering) mention the divergence of members from architecture, interior design, and architecture field and they want to enlarge their knowledge area in makerspaces.  While there are different work definitions in the area, a variety of tasks are seen as an opportunity by makers. While different tasks require different expertise, shifting among them is a smooth activity with their desire of making trials. One of the interviewees illustrates his role taking as below:

> In fact, we are divided into groups; some are in contact with the families of the children since the prosthesis hand we will produce needs to be measured; some go to take measurements, there is a printing process... I've been in all of them so far. Actually, there are no very strict rules in this work. I worked in all of our groups. *Participant 4, Member, Mechanical Engineering*

Since makerspaces carry out projects related to technology, design, art, science fields, there is a common judgment that maker profiles should correspond with that. However, people from different professional areas may have interests and expertise in these topics. As an unexpected story, one of the makerspace users shared its observation:

> For example, a lawyer was attending the project. People from very irrelevant professions also came and gathered together quite a lot. Architects know the design part of the job, but the lawyer guided us in production surprisingly. It is very nice that different disciplines come together and produce. *Participant 10, Founder, Mechanical Engineering*

Leaning on the production makes even a lawyer an expert in such a case. Change in their position in the team reveals that their interest takes precedence over their disciplines. Since the leaning of the makers is an important factor while forming teams, it is possible to form teams in the blurred areas where the junction of professions is observed. Their leanings initiate their interaction while they discover the blurred area.

#### 4.2.1.2 Diversity in Disciplines

Makerspaces consist of people who are from diverse sets of disciplines with their motivation to make. Throughout the research, there were participants mostly from industrial design, mechanical engineering, electrical and electronics engineering, and administration fields. Also, these participants share their observations related to the diverse environment in the space. Different perspectives in the makerspace are welcomed by the makers since they interpret the interdisciplinary environment as an opportunity.

> We were already working with different people from different fields at Case 2. Since technical competencies were provided in training, we did not have much trouble in that area. We had friends from sociology because it was a volunteer project. We had volunteers from business and engineering; we had volunteers from design. Throughout the process, we were working with people from many different fields. We work in this way all the time; it is actually fun for me. Because you can learn about different perspectives, additional information, you can complete the missing places. Therefore, it can be nice to work with people from various fields. *Participant 2, Member, Industrial Design Engineering*

It is also emphasized by the interviewees that knowledge required is gained through workshops that ease the involvement of diverse disciplines in the area. While participants value diversity in the space, it is supported in the organization by interrelating these fields. The environment is defined by the makerspace facilitators as independent from engineering and design. It is also expressed that this diversity shows some extremes too:

> We are actually trying to introduce them by saying, "There are people who come not from engineering or design faculties, but from psychology, which does not look very familiar like your discipline; there are also people from gastronomy." There are also, for example, class differences. There may be differences in recognizing us; there may be differences in abilities. We always try to see it as something positive. *Participant 7, Manager, Industrial Design*

Although fields like psychology and gastronomy do not seem directly related to productive maker activities, the creative perspective of makerspaces enables collaboration with these areas. Interviewees emphasized that the space is open to use by individuals from different disciplinary backgrounds. The binding element in the community is the knowledge that makers share. Makerspaces make calls for their activities such as training or a project. One of the interviewees stated that:

> There are many fields, even students from law faculty can apply. Even students of business and economics faculties can apply. In other words, this is entirely dependent on the person's wishes; we do not make any restrictions on disciplines. We made an outreach about Arduino 101 training, which is related to the general definition of Arduino. We do not make any distinction here. We say that anyone who wants to learn can come. We received many applications from the faculty of law to the academicians there; even the academician wants to learn this, so we gave them training. *Participant 5, Employee, Electrical and Electronics Engineering*

To sum up, the diversity of makerspaces are not limited to the engineering or design faculties, many different disciplines relate their expertise with the making in a creative way. Also, some people become concerned about other fields due to their personal interests not because of their discipline.

#### 4.2.1.3 Non-Disciplinarity

As discussed in the previous section, makerspaces include various disciplines. However, the emergence of the disciplinary concept in makerspaces should be investigated separately considering the experienced disciplinarity by interviewees. Participants of the research mostly emphasize that rather than disciplinary differences, they interpret the collaboration in the makerspace as a non-disciplinary working environment. While there is no strong perception of the disciplines, there is an effort to elevate the notion of creative making without the concept of discipline. One of the important aspects of non-disciplinarity in makerspaces is the precedence of eagerness to produce over disciplines. One of the interviewees' remarks that:

> In general, there is no requirement to participate in our project. You may not be a designer; you may be doing another job. The important thing is to want to produce together, to love to produce together. *Participant 10, Founder, Mechanical Engineering*

While discipline is not an identifier to be able to make, interviewees draw attention to how disciplinary identities weaken in the community. Motivations of the members become the main prerequisite to involve in projects. One of the interviewees share her opinion about one of the makers in the community as follows:

> Inside Case 1, there is Participant 7 as the general manager, not the founder. She's an industrial designer, so it's easy for us to get along. Apart from that, there is Participant 6. He is also an engineer; I don't remember what engineer he was. *Participant 12, Part-Time Employee, Industrial Design*

Through the same interview, the same person is introduced as both a mechanical engineer and an electrical and electronics engineer. It shows that even there is a strong environment of sharing, it is happening without questioning disciplines. Their disciplines become unperceivable over their activities in the space. Therefore, collaboration is achieved by focusing on the shared knowledge and interest.

Since collaboration in makerspaces is defined as independent from disciplinary areas, it also emphasized that new frameworks are created while combining extreme disciplinary edges. One of the interviewees from the makerspace organizations mentions how they prioritize enabling that integration. Gastronomy students find a chance to use 3d printers as a mold for desserts after meeting with the makerspace.

> Yes, we take a discipline, but this discipline doesn't have to be something that completely limits our lives. What we blend it with is very important in this world. We have to think about this; we have to think about it a little bit. The gastronomy student also says I don't know how to do it or combine my discipline with 3d printers. *Participant 7, Manager, Industrial Design*

There are also methodologies improved to enhance the integration of disciplines to create a collaborative environment that inspires transformed products. One of the interviewees explains her methods used in the area to illustrate how they form that relationship. Makers are asked to write their professional areas and interests on the board and they draw circles randomly. Intersection sets are combinations of the maker's expertise and interest, and these intersections become interaction points for them. In these regions, disciplines are transformed into a new framework with an interactive environment.

> For example, a very interesting project came out between a coding student and a student who knows sailing. They discussed why there is no product design about sailing or why the sail figure cannot be the main ingredient of a game design? For example, one of them has a perfect knowledge of sailing. The other is also interested in coding. A business idea where two of them meet can even come up. *Participant 7, Manager, Industrial Design*

Although makerspaces show a diversity of expertise in the space, there is a strong emphasis on the motivation to learn and produce apart from the discipline concept. Rather than defining these people as belonging to a discipline, they appear with their independent knowledge set and willingness. This aim helps the team to collaborate without any prejudice and superiority.

Although there is an emphasis on learning and practicing new fields of applications, there are some projects that require the contribution of experts who had the education of that specific discipline. Members of the makerspaces value their opinions as presented in the below quotation.

> In more difficult cases, we have a doctor and physiotherapist friends. They were usually consulted. Would it be possible if we produce such a hand? For example, maybe the kid has 2 fingers. He's already doing his job with them. Making a hand will perhaps make their fingers weak. Maybe it will be worse for him. Would it be useful to do it or not? Will it wear out there after a while? For example, some people had wounds around their arms, we consult with doctors or a physiotherapist friend in order not to cause harm. Of course, doctors or physiotherapists know better than us. *Participant 1, Member, Electrical and Electronics Engineer*

While there is a diverse population from various disciplines, their leanings override their disciplinary perspectives apart from some tasks that require expertise. Therefore, non-disciplinary collaboration is achieved in the makerspaces with the non-classified makers. Since leaning of makers leads them to involve blurred areas, collaborative learning becomes important in these regions. In the following section, learning practices will be explained in detail.

### 4.2.2 Collaborative Decision Making

As the projects carried out in the makerspaces require various fields, it is inevitable to have decision moments. The majority of the participants emphasize that there is a decision process without any conflicts among members. Disciplinary borders are not strict and makers are giving value to new ideas. While there is no certain definition of disciplines, experienced people in the area also become significant decision-makers.

One of the participants mentions that there is a positive attitude towards new ideas in his early attendance to the community. It is outstanding that makers who know about a topic become a consultee even if he is new in the community.

> I came there as a first-grader, even as a preparation school student. Normally, I appear like an inexperienced person, and people don't ask too many questions to such a person. Unlikely, I was asked tough questions in Case 1. For example, my opinion was taken while doing a project. It was nice to get my idea on that amphitheater project, for instance. It might not have been. There is excellent coordination within the group. This is reflected in you as well, and you are involved in the project in some way. When I said a problem, that problem was taken into account. When I say we have such a deficiency, they provide it directly. I don't remember any of my ideas being considered worthless. Even if it will not be realized, it has listened in the group. *Participant 8, Member, Mechanical Engineering*

Also, there are outstanding effects of experienced makers on the decision process. Makerspace facilitators who have various expertise guide the makers along the design process. Decisions are more controlled by them with the compliance of the makers.

> It is most likely discussed whether the model is suitable for CNC or which machine can be used for it. Also, since it will be a thick solid body, we do not cut it in the laser machine because it will be more than 2 centimeters. We directed it to the CNC once. If he doesn't have any knowledge about wood or doesn’t know which device can be used, we guide him. For example, I would be giving information there; you would probably be better off machining that wood in CNC. You can have these sandpapers to polish it, and we can get the desired texture you want. *Participant 7, Manager, Industrial Design*

This compliance is more related to expert opinions but there is also a hierarchical structure arising from the experience in the community. Since the organizations are not defined with a strict structure, there is a transition between two main subgroups, newcomers and active participants. Most of the participants reveal that there is a core team that is formed naturally with active participation and taking responsibility. One of the interviewees confirm that idea as follow:

> Our friend [the community manager of Case 2] is officially the coordinator in Ankara. But [the community manager of Case 2 is not the kind of person who has the responsibility and bosses around; she was never a bossy person. We generally made decisions with our active colleagues. Over time, this turned into a team. Let me say after a while; we turned into a coordination team. I should say that volunteers who come frequently got to know each other and formed a round table. Decisions started to be made in this way. We speak as a team and discuss. *Participant 2, Member, Industrial Design Engineering*

As described above it is seen that experienced people have more say in the community and it is taken normally without any hierarchical concern. There is an open environment to discuss and make decisions. Both newcomers and active participants are encouraged to share when they know something that contributes to the decision environment.

### 4.2.3 Collaborative Learning Practices

Makerspaces as a new collaborative framework are generating a distinctive learning practice. With the introduced tools, mindset, and methods, participants of the space obtain the maker's know-how. Makers in Case 2 define their learning process about taking measurements, modelling, 3d printing, post-processing, and assembly. These processes are taught over workshops focused on the prosthesis-making stages and experienced through projects. Also, members of Case 2, mention the importance of learning from peers too. In Case 1, there is a wide range of workshops covering various fields. Learning through open source and peer learning is stated here. Learning practices in the space are classified into four main headings as peer learning, workshops, open-source, and learning through tangible means. An interactive learning environment is enabled with both social ties in the community and physical facilities.

#### 4.2.3.1 Peer Learning

In the collaborative environment, participants find that learning from a peer is more valuable and easily reachable. A collaborative environment in the field enhances the sharing environment with diverse knowledge of makerspace users. One of the interviewees states how learning from the peers in the space is possible with the following quote:

> Let me say this before I started Case 1; I was not that multidisciplinary. I was doing things that I know more about. I didn't know that much about design. Since Participant 7 is a designer, I can say that she has opened my horizons in terms of design. Apart from that, I also progressed in my field. For example, I am a mechanical engineer. But I also learned how to draw PCBs. I moved a lot in the electrical and electronics field; I was curious in the past. Still, for example, my teammate knows more about electrical and electronics, and I learned a lot from him. Working in the community made me more multidisciplinary. *Participant 6, Employee, Mechanical Engineering*

Makers are focused on the end product and the necessary knowledge to obtain the product requires diverse disciplinary knowledge. With the help of a multidisciplinary environment, it is possible to learn from peers. During workshops given in the makerspaces, rather than asking to tutor, the person next to you becomes a knowledge source. The social environment in the space supports the individuals to interact with each other since the motivation to learn is a common feature of the makers. It is also encouraged by the makerspace facilitators to establish dialogue in subgroups.

> When you cannot do it, if the trainer is busy, your friend next to him helps. I did that, you can do that, for example. *Participant 11, Member, Mechanical Engineering*

As stated in the above example, learning from peers is preferred since it is a rapid action to gather knowledge with social interaction. Besides quick response, the experience of the peer is also found valuable too. Most of the participants emphasize that gathering the knowledge from a person who has experienced that failure before is more condensed information.

> I'm making a mistake, but I can't directly ask open-source or find that error. Maybe it takes me hours to find the error. But if I find someone who made this mistake and asks, let’s say, Participant 6, I'm making a printer, the printer's extruder is clogged, and I don't know how to fix it. Participant 6 is coming. He says that's the problem, that's it. The question that I can solve in 2 hours can be solved in 5 seconds. It is best to ask people. *Participant 8, Member, Electrical and Electronics Engineering*

The evidence presented above has shown that makerspace demonstrates an area to get the necessary information with a social environment. Makers are open to sharing their expertise and social closeness enables an assistive environment. Regarding that makers experience similar paths, it is seen as valuable to share this know-how.

#### 4.2.3.2 Workshops

Workshops are a common way of transforming knowledge or experience in a practical way. Learning culture in the makerspaces is mostly related to products or means to design that product. While one of the workshop topics is selected as stamp making, another one aims to teach 3D modelling to design a product. In order to bring in knowledge in the makerspace, it is preferred to practice it through workshops. Workshops are facilitated by makerspace facilitators according to demands in society and necessary skills in the space. While sometimes the learning process is supported by experts from outside the community, it is observed that workshops held in the space are created and improved with the inner dynamics of the society too.

> Our coordinator does not provide communication training; we have a psychologist outside of our coordinator team and we take a particular lecture for communication with children at the age of preschool. They give this

> training. Other pieces of training are given by the coordination teams to volunteers; training in robotics, how to measure a hand, how to model it, etc. It goes like this. *Participant 3, Member, Business Management*

Experts in the community share their knowledge in order to transform their experiences into newcomers. Apart from that, makers who have specific interests and knowledge are supported to share their know-how. With this sharing environment, a sustainable learning environment within the community is achieved. That process establishes the sustainability of the community's knowledge via its inner dynamics.

Interviewees illustrate that the scope of the workshops requires multidisciplinarity since different expertise are covered throughout the production process of workshop subjects. Therefore makers who have specialized in an area become a knowledge source. Gathering the knowledge is achieved through the interaction between makers and the makers who have expertise. Roles of the space-makers are given in the following quote with their different expertise that is transformed to other members.

> For example, let's say, design needs to be done first; Lady Participant 7 comes and tells the design process for 2 hours. She mentions the points that need attention. After the design is finished, production will be started. For example, there will be a printed model. Then, Participant 6 says that the modelling is done as the following process. You can give the dimensions like this. For a part in these dimensions, you should have at least that much thickness to print it. After things are prepared, the rest is my part. What equipment can be used in the following? What software works can we do? Or what should we do on Arduino? Which Open Source library should we use? What can you find on the internet? After giving the information, the friends gather and start doing it. *Participant 5, Employee, Electrical and Electronics Engineering*

Although workshops are events that are organized in detail, there is a more informal process carried out besides. With the community relations between makerspaces, it is possible to arrange workshops with the people out of the makerspace but involved in maker culture. Maker network enables them to solve the problems they confronted with the close relations One of the interviewees states that:

> For example, we have a training called "batterying". We have a friend named Felix, who is not in any of our team, but a very supportive person, he gave that training. The information we received from there explained what kind of battery we should choose for which electronic device, and everything about them. After that, we do our job, or we are stuck somewhere, we revisit Felix, and he supports us in that regard. If there is anything about drones, there are Arthur and Kevin; there are many people we visit. They complete our shortcomings. *Participant 9, Founder, Mechanical Engineering*

Using both the inner experience of the makerspace and the maker community relations, the learning process is supported with workshops. Makerspaces also provide practical learning with their physical meeting space and prototyping facilities considering the practicability while learning. The common environment they use enables different disciplines to shift across their fields as given in the below quotation:

> There were more electrical and electronics engineers, but computer engineers wanted to build the circuit. They write the code but want to learn how it works electronically. Also, mechanical engineers attend too, they don't have any knowledge related to the topic but they want to learn. In fact, they usually come to this kind of training to learn something outside of their profession. *Participant 5, Employee, Electrical and Electronics Engineering*

Since workshops held in the space are open to everyone, participants who have questions in their minds can learn the practice of other disciplines. These workshops become the promoter of their curiosity to enlarge their field of knowledge.

#### 4.2.3.3 Open Source

Makerspaces are centers that enable collaborative learning in a physical environment. Although learning practice is usually observed as peer learning and workshops in the makerspace environment, there are also online tools to improve the learning practice. Open Source is the knowledge database formed collectively by makers. It is possible to reach 3D modelling of a prosthesis or coding of smart personal assistance via the internet. It is noted that Open Source is commonly used by participants while studying a project. One of the interviewees claims that Open Source preferably is used to ensure accessibility to knowledge.

> We pay attention that almost every project we do is Open Source. For example, one of our projects, personal assistants, has a platform that takes IFTTT as a baseline. It was an open-source platform for weather information. We were generally following the data from the IFTTT Open Source code. When it comes to design, there are open source design sites, Thingiverse, and Grabcad. There are a lot of designs available to everyone. We get help from there and tell the students that there are a lot of designs. You can look at them and get inspired. Other than that, like Tcad. We use the program, and it is an open-source program. If we have the chance to use Open Source in a project, we use Open Source so that everyone can access it. *Participant 6, Employee, Mechanical Engineering*

Aside from getting benefits from the open-source, it is encouraged to transform experiences to the open-source too. While a person develops a project and shares the knowledge set required on the Open source, He/she generates a guide for the maker community too. The concept of knowledge transfer is enlarged with the online environments which maker culture sustains. One of the interviewees shares his thoughts relatedly:

> For example, we made a product, a project. We gave training, let's say. After one completes his training, he can upload and share on his own on the Instructables page. Because there (in Instructables) a product is placed. It includes information about the details of the product and its sources. He can transfer all the details there since he learns them all. *Participant 5, Employee, Electrical and Electronics Engineering*

One of the interviewees draws a different frame for the usage of open source. Since open source requires searching capabilities to find a solution for the project, it may take more effort to reach the necessary knowledge set. He emphasizes that the ease of reaching the person who has faced similar problems during that project is practical in comparison with open-source research.

> For example, he had some difficulties; he always had resources. We are the sources there. If we assume that the time allocated to the project is an hour or so, it isn't easy to search for resources there. But considering that we have done many projects before, we are open-source there, and we know what

> questions we will face since we have done this before. *Participant 8, Member, Electrical and Electronics Engineering*

While the interviewee finds it difficult to gather data from open source, his perspective on the knowledge created in the community supports the concept of community knowledge in that specific maker society. The idea of community knowledge is supported here as defining makerspace as a physical knowledge source.

#### 4.2.3.4 Learning through Tangible Products

The learning process in the makerspace differs because of the means it uses. Since the production facilities are more integrated into the environment, the learning process is frequently carried out through tangible means. Participants of the research explain their learning process as directly benefiting from the tangible workshop prototypes. One of the makerspace facilitators identify the learning process as follow:

> He models, produces, designs, and turns it into a new product with the education he learned. In this way, it becomes a product of his own, while at the same time, he is learning this product. *Participant 5, Employee, Electrical and Electronics Engineering*

Throughout the design process, required knowledge is experienced by the makers over a product. One of the participants made a comparison of the workshops held in makerspaces and the design ecosystem. While workshops follow up conceptual design and basic prototyping in the design ecosystem, makerspaces take it a step further with enabling the implementation with improved production.

> We do things like training and workshops. We did urban hacking workshops. We did one of them with [historical place in Istanbul]. There is a concept called urban hacking; we put a flower pot or something else somewhere. We wonder whether we can do these workshops. I have not seen such training in the design ecosystem. They come to training; the concept is discussed, a model is made, and stays there. This has an advantage for the student. But for example, we thought that a workshop where they made the final product would be more suitable for us and designed such a three-day module. We went out on the evening of the first day. We took photos everywhere, and

> measures were taken. We went back to the workshop with incredible photos and measurements. From the beginning of the second day, we were talking about what kind of hacks we can do to the places we photographed in the workshop area. There, the whole day is spent almost brainstorming and thinking about design. Brainstorming was being done; there was a hole in a wall, what can we put in there. Then we created sketches for this place. We started making the digital model over the most liked sketches. The second day ended with the completion of the digital model. Next week we produced them. After producing, we went to the field together on the next weekend, on Saturday or Sunday, and installed them in the places we thought of hacking. *Participant 10, Founder, Mechanical Engineering*

The physical product which is obtained while trying something becomes a learning material. Experiencing over a product eases the understanding process. Also, creators of the products experience the output of their efforts.

## 4.3 Spatial Dimensions of Collaboration in Makerspaces

In order to understand the collaboration in makerspaces, it is also important to understand the spatial aspects. Participants of the makerspaces act in a space with its elements, and interaction between members and space affects the collaborative action here. Since makerspaces provide a meeting area where members carry out projects, it should be analyzed how spatial elements change the way they interact. Makerspaces include production facilities, working desks, meeting rooms, and so on. While analyzing the spatial dimensions of collaboration in makerspaces, space, physical equipment, and prototypes that create means to collaborate are examined. While some of the makerspaces, Case 1 and Case 4, use a dedicated area for their activities. Some, members of Case 2 and Case 4, use distributed spaces where they meet their requirements. For both different usages of the space, collaborative action is analyzed through their own spatial elements.

### 4.3.1 Space as a Collaboration Enabler

Collaboration takes place in a physical space with its provided environment that enhances interaction. Throughout the research, maker areas located in universities and public areas are investigated. While universities are supporting the maker culture by giving a physical space on the campus, there are also nonprofit enterprises that make activities in more flexible areas. Within the makerspaces investigated through this research, there are different uses of the space. One of the interviewees shared their usage of distributed makerspace:

> We don't have a place where we gather all the time. Actually, there are dwellings that we use. There's no direct Case 3 address. But here, for example, [a 3D printer company] in Istanbul is an area that we can use for a meeting at work. [an incubation center], [a coworking space] provide us with environmental support, especially in our projects. There's [a coworking space] in Kadıköy, you can look at them, they're quite different. There are different places, according to our needs. For example, there will be an interview and we need to shoot indoors, we will use [a coworking space]. For example, something should be produced with 3D printers, and we will make modelling, and we will produce it. If there is a need for 2-3 3D printers, we go to [a 3D printer company], we work with them. We're acting on what we need. *Participant 10, Founder, Mechanical Engineering*

In the context of university makerspace, it is remarkable that diverse environments of the university can be gathered together with the eagerness of the university shareholders to make. Participants of the research mention the use of the space by university students who have production requirements. Students, academicians, associations, university personnel come together to use the area. While academicians use the area to work on their prototype for research, they also attend space to spend time on their hobbies. Also, associations in the university meet with space in order to use the makerspace facilities in their events. One of the makerspace members confirms that:

> For example, a dance group had a topic about the devil and the angel. They downloaded all the products in the choreography about the devil they made and used it from open source. They didn't know that they could download and use it. I mean, they don’t know about printers. It's a bunch of girl groups

> studying in different departments. Here they downloaded a mask, they argued between them, let this be. Let's make the spear-like this; let's make the spear handle with the handle of the ground mop. They came up with that idea. Here's like, let's paint with that spray. *Participant 7, Manager, Industrial Desing*

Since the dance community prefers to design their own stage props, makerspace in the university provides an environment for them. Fulfilling their requirements, they meet with the place and experience the making activity through collaborative action. While a variety of groups are using the space, there are participants who attend regularly. These participants of the makerspace are encouraged by the makerspace facilitators by naming them as “Young Makers". There are makers who are more active in the community and have organizational responsibilities. These part-time workers are involved in the community with their high level of attendance to events and use of space. Arranging their time schedules, the purpose is to have disciplinary cohesion in the space and encouraged to launch new projects within these teams.

> The interdisciplinary interaction started with our part-time students. He says that Wednesday afternoon is empty; I can be there at that time. So, two students may intentionally intersect on that day. For example, let's say we have a design project; we work on Wednesday afternoons. Here we had a board; you know that you can come according to the board when everybody comes. Generally, we do something every day, one part-time student is with us, we say stop at noon, or when we leave or something, sometimes they can stay in the evening. For example, Participant 6 is arranging himself; and he said that we would stay tonight and work. It is a desirable situation there; we felt that multidisciplinary way of working. *Participant 7, Manager, Industrial Design*

It can be deduced that space is an interaction enabler among makers in order to enable the junction of different practices. Makerspace facilitators’ effort to increase the diversity in the space makes it possible to do collaborative projects in the area. Also, members of the area are intended to work together and know each other’s plans with interactive boards in the space. Therefore the use of space in a timewise way encourages members with the desire to come up in the area. Also, sharing a common space enables the communication between makers about their projects. Initiating small talk in the makerspace on a project is commonly welcomed and creates social ties among makers. With their diverse interests, it is possible to launch collaborative projects.

> Collaboration sometimes goes like this. The student has fellow students. Or the one who came across from different departments in our workshop. "Hello brother, what are you doing here?" He says, "Here, I am trying this. " and he says, "Should we do it right here on my skateboard?" For example, he was building a plane, a small plane with Arduinos or something. Like helping him. Someone was dealing with an electronic guitar amp. Then ask someone to help with brazing. *Participant 7, Manager, Industrial Design*

Also, makerspace enhances the interaction with its spatial design. The arrangement of the working area influences the collaborative environment. One of the interviewees drew attention to how interaction can be related to the layout of the space.

> They can see each other because they are sitting in an open space. So they can analyze each other's situations, wondering what they did. Having such an L or U shape provides more interactive participation. For example, when I was doing something, someone came and said, "What are you doing? Can I watch it?" they say something. *Participant 12, Part-Time Employee, Industrial Design*

Interaction in the space is related to their sharing environment. Since workshops are carried out through the same projects, participants tend to examine the works of other participants. The physical layout of the space becomes important at that point in order to improve visual interaction and enable face-to-face communication in the area. Also, one of the participants emphasizes the creativity enhanced with the spatial design:

> I think the color of the makerspace area is also very important for collective work. It has a yellow background and I think it's very affecting, changing the atmosphere. The furniture there is different, there are spaces for collective work. I mean, it's obviously a creative field. Because there are 3D prints on the walls. I think it's an interesting area, they intentionally located them in a visible area, so people would want to try them out. *Participant 12, Part-Time Employee, Industrial Design*

The spatial design of the makerspace boosts creativity and collective work. Their installation of 3D prints on a wall enables an area that calls the attention of the members. These meeting points enhance the interaction in the space. Considering the design process of makers, it is also important to have a flexible environment during prototyping. There is also flexibility provided in the space with areas to work collaboratively.

> They work wherever they feel comfortable. We have a vertical prototyping area in the middle. We made a surface completely wood like this. We can screw and unscrew whatever we want. We also have a horizontal prototyping area in the training area. They can clean what's on the tables and do it there too. We also have a flat area in front of that extra vertical prototyping area. We also have a flat area in the workshop. One is with a high seat and a low seat, which can work in the appropriate area according to the project they make. *Participant 7, Manager, Industrial Design*

Space becomes a uniting element for people from diverse interests. With the physical environment, face-to-face interaction is possible which leads to creating social ties. Their interaction around tables gives them a chance to get to know their projects and share their opinion. With this shared environment, collaboration among makers is achieved. Also, there are meeting areas where the production facilities are positioned. One of the interviewees mention how members from different disciplines interact in that points:

> For example, there is a direct cut here, engraving here. I have engravings at these points. Other than that, for example, there are very few cuts here. I've seen this thing. When I was in space, there were a lot of architecture students, designers. So I got used to it because there were so many things like that. I already knew what this cut would be like. I'm a bit inexperienced at soldering but I am familiar with it from the space. It is not surprising to me. *Participant 11, Member, Mechanical Engineering*

Makerspaces include areas where the production facilities are located. Around these areas, individuals may contact the people using that machine. These places become a meeting area where they can observe and learn from each other. While these spaces become hotspots of the makerspace, there are areas used for more individual tasks.

> The most popular point in space is the training area where most people come. But for me, under the ventilation is my favorite. Because I work there. I've been sanding there all day. I'm just listening to music and sanding, a mask in my mouth. *Participant 11, Member, Mechanical Engineering*

It is seen that there are different uses of space collective to individual use. While members of the space interact in the hotspots, they also prefer to use some areas individually. While the interviewee prefers to use the ventilation area, there is one interviewee who prefers to use a soldering table alone.

### 4.3.2 Physical Equipment as a Collaboration Enabler

Makerspaces have a wide range of physical equipment in order to use in production. 3D Printers, Laser cutters, CNC machines, hand tools are general items that are associated with makerspaces. There are also physical means like a work table used for painting, sandpapering, or brazing. Apart from these prototyping areas, desks used for collaborative idea generations are available in the space too. Interactive desks or boards are mostly used for brainstorm sessions. The following explanation demonstrates the usage of the desk as a collaborative work area:

> The tables have a surface that can be written and drawn. I'm very used to these tables from where I used to work. I can start working right there. It is very useful; for example, we have such a discussion environment, or we have a glass wall on the side facing the kitchen, we use it as a blackboard, and it is good. We usually say an opinion from there or discuss it there. For example, when we are three people, we either gather in one place, so we collect in front of you on a surface that you can draw and write on the table, or we can change it according to ourselves. Something like that happened; we were trying to produce a prosthesis for a disabled friend. At that time, two academics, a person from the sports center, a student, our team, and our disabled friend's brother, came. At that time, for example, we gathered around the table in the workshop area, where he tried the models. In other words, we do the small prototypes we make on the model, for example, measuring and discussing the details; in two minutes, there is already a tiny place on the table and a mat to make a model. *Participant 7, Manager, Industrial Design*

As illustrated in the above quotation, both physical elements in the space and prototyping equipment provide makers to develop their ideas in the space. With the attendance of various stakeholders, creative usage of the space equipment enhances the collaborative environment. Equipment that enables collaborative idea generation and making prototypes are gathering people together in space.

Since makerspaces that prefer to work in distributed areas need physical tools to carry out their projects. While they can work in various ateliers or coworking areas, there are alternatives like a cafe or a home if they have the physical equipment with them. Most of the participants mention the importance of the physical equipment compared to physical space as follow:

> I have assembled with volunteers even at home because it is a more comfortable meeting area. After all, if we have tools and materials, we can assemble them anywhere. *Participant 1, Member, Electrical and Electronics Engineering*

Participants from the maker societies which have changing working spaces put emphasis on physical equipment rather than having a maker lab. With the social environment and physical equipment, it is possible to work in alternative sites. Another way of viewing this, rather than making the production possible, physical equipment introduces innovative production methods with enhanced tools. Participants of the space have experience with limited tools. With the enhanced facilities in the environment, it is also possible to learn new fabrication techniques. With the effect of this innovative production environment, the perspective of the makers improves simultaneously. Knowledge set of these facilities transformed to the makers with the collaborative sharing environment. The remark of one interviewee on the change in makers' perspective with the introduced tools in the makerspace:

> He's doing it in his house but thinks you can do more there. Let me give an example. Let this person make products from resin. He does not believe that you can process the products made from resin in CNC there. Or he doesn't think he can come and drill with Dremel. You see, that person was dealing

> with resin, but if we established such a relationship with CNC, it turned into something else. *Participant 7, Manager, Industrial Design*

Shared knowledge about fabrication tools enables makers to reach another level. Every machine or technique introduces an individual to make new trials while learning. Also, production facilities in the makerspaces are attention gatherers in the space. With the help of space-makers or experienced members, they recognize the potential of the space. Discovering the potentials of this equipment is possible with the curiosity that members of the space show each other. Their discovery process is shared by one of the participants as follow:

> For example, one of our students was obsessed with leather, and he brought it to us to wonder if we could cut the leather. He's a student who can draw, and he makes normal cuts. He brought some pieces to see if we could cut them with a laser. So we found out that it is possible, also we tried the felt, and that's where we found out. *Participant 7, Manager, Industrial Design*

These conversations become possible with both facilities available and the positive attitude to make new trials. While space-makers support these trials, members of the space also feel free to use the equipment. Also, most of the interviewees emphasize the effect of physical equipment on newcomers. One of the interviewees states the effect of fabrication tools on the people who walk in the space during an exhibition.

> During an exhibition we held, the 3d printer there attracted a lot of attention. The students did not know what was happening there, but the printer works; some came to ask why it works and what it is doing in the middle of the exhibition. *Participant 7, Manager, Industrial Design*

As indicated above quotation, makerspaces include different interaction points, these interaction points may include areas where fabrication tools are located. Therefore 3D printers or laser cutters become a collaboration point. Makers’ products are used as an exhibition item. These initiate the awareness of the new members to interact with the product and the makerspace users.

### 4.3.3 Prototypes as a Collaboration Mean

The design process in makerspaces is associated with the production process mostly. Although design stages can be listed as problem definition, research, idea generation, prototyping, implementation, most of the participants are illustrating the design process over prototypes. The nature of this process is arising from the characters that centralize the prototype over the process. Since makerspace provides that working style, with its production facilities. One of the participants points out her way of working as:

> I always preferred to work with mock-ups. So I would make the mock-up, take a photo of it and model it. Let me say that I do not make models first and then mock-ups. I do not work in such a mindset; first, I make sure that the design is working on a mock-up, and then I model it if necessary. *Participant 7, Manager, Industrial Design*

As indicated above, prototypes become the tool they carry out their design process. Knowing that makers prefer to work with mock-ups individually, means they have become a common tool to work on it. They explained the use of mockups through the design process. For example, It is shared how they follow a design process in their electronic prosthesis arm project. One of the interviewees confirms that with the quotation below:

> While working on the electronic prosthesis arm, first, we were explaining the concepts through our 3d model and sketches. Then we continued to work on the prototype to discuss and test the design. *Participant 2, Member, Industrial Design Engineering*

Although they are using sketches or 3d models to initiate discussion, mock-ups are used in the upcoming phases of the project. They tend to see the concept in their hand and discussing the tangible means is more effective for them. This perspective is spread in the community since they have the opportunity within the space. One of the participants defines a philosophy called “Build-Design-Rebuild”. This is the methodology that is encouraged to use in order to reach the mock-up as soon as possible.

> We start with the Build-Design-Build philosophy. With paper, cardboard, whatever you get, do it first. There is no design; we do it first. At first, we do it with all that we have. What is missing, we take care of them. *Participant 9, Founder, Mechanical Engineering*

They aim to have as many prototypes as possible during the process. It is not important to have the complete product, it is important to follow the process while recognizing the deficiencies through testing mockups. Interviewees state that giving feedback and having discussions over the mock-ups is more practical too.

> When the design concept is clear in their mind, the mock-ups begin to emerge from their sketches. Those who want to give feedback through mock-ups give feedback. *Participant 10, Founder, Mechanical Engineering*

It is possible to share opinions and give suggestions about a design. A collaborative environment is achieved with the exchange of ideas. Since makerspaces have the opportunity to make iterative progress, it reflects positively on the implementation process too. One of the interviewees emphasizes practicability in the space while they give their end products to the user:

> We do a trial before handing it over to the children. It is necessary to make changes to the model. It is done in a loop like this by making changes on the model, trying again, making changes, and making changes too. This is actually the first model that is not always suitable because there are cases that we have not encountered before. *Participant 3, Member, Business Management*

Being close to production facilities makes them feel free while improving their design. And, they also digest the iterative design process through their experiences. Building on the idea that there is a dynamic making process in the makerspaces, there are means created by the makers which enhance interaction. Although individual projects cause them to work alone, the curiosity of the makers directs them to interact with the other's projects. Most of the participants state that there is always communication between makers which is triggered over the product. They tend to follow the progress and the methods other members use. Knowledge sharing and compliments about the product are creating social ties among the makers.

> You run, run, throw, and it glides by itself; there are such big models. One child was doing it, for example. One day I went and asked. What are you doing, what is that? Because you want to ask. Do it like this, or like this. There is an exchange of information. When someone comes and says what are you doing here, it feels very nice or something like that. Someone said, did you print this on a 3D printer? I wanted to print something at my house, maybe a trinket. *Participant 7, Manager, Industrial Design*

When they come up with someone's product, they start a conversation through the produced means. While learning the process which the maker experienced, they can share their own interests and plans too. Also, facilitators in the makerspace are aiming to increase interaction via introducing projects which enhance interaction among makers.

> In general, there are projects, for example, things are done to combine coding and design. It is also cared about to attract people's attention with projects. They were making a Christmas box and laying it out when the two people held hands; the music played as the circuit was completed. They had put this at the entrance to the school; everyone was trying. For example, there was a photo bot; it sent photos to Instagram when you pressed it. Generally, things were done to increase such interactions among the people who try these means. *Participant 12, Part-Time Employee, Industrial Design*

These products are intentionally designed by space-makers to attract people's attention. Through these products, they experience the capability of making their own design in the area. It enables people to interact within the surrounding environment to spread the making. It is also seen that members of the makerspace help each other in their projects. Since they share the same area, they come across when someone needs help in his/her prototype. One of the interviewees mentioned her experience while trying to find alternative solutions to a problem with the help of other members.

> In Case 1, I learned what laser cutting can do and what 3D printers cannot do. For example, I had never combined laser and resin before. That is how different materials interact with each other. For example, I pour the resin; it disappears, MDF absorbs it. But I didn't know because I haven't done it before. Then I said, let me varnish, I tried, but that didn't work either. Then we greased it with heavy oil. At that time, it was not absorbed, but this time the color was getting yellow. We had trouble doing it. Because it had to grow,

> and the resin dries out in a day. When it dries, secondary treatment is required again. All part-time employees helped me. Someone was oiling; someone was helping to pour the resin with me. *Participant 12, Part-Time Employee, Industrial Design*

When someone experiences a problem through prototyping, others give support with their knowledge or skills. Production phases carry on with collaborative iteration. Various alternative fabrication methods can be used in makerspace. These methods can be tried iteratively through a project with the shared knowledge. Learning from a prototype maintained with collaborative trials and errors.

## 4.4 Social Dimensions of Collaboration in Makerspaces

In order to understand the collaboration in makerspaces, it is also important to understand the social aspects. Members of the makerspaces form a social environment, and within this social context, collaboration takes different forms. Since makerspaces provide a meeting area where members carry out projects, it should be analyzed how social elements change the way they interact. While analyzing the spatial dimensions of collaboration in makerspaces, maker community, partnerships in the space and supportive environment in the community are examined.

### 4.4.1 Maker Community

The Maker Movement spread around the world, with a strong philosophy behind it. People who support individual production against consumption culture, raise awareness within the maker culture. This perspective is scaled within the maker communities in order to represent this culture as a society. Involving a community changes the notion of collaboration considering the common ground founded. Most of the participants emphasize that having a common goal eases collaboration.

> Yes, everyone has the same purpose, and people who come with this purpose are alike, so it is easier for them to be friends. I mean, I also have friends in

> other communities, but too many Case 2, as I said, we are together for the same purpose. This purpose connects us. *Participant 3, Member, Business Management*

One of the participants claims that the population who attend the makerspaces are open to learning and also open to socializing. Bringing together these personalities into space, create an easily achievable collaborative environment. One of the interviewees states that it is a natural process:

> The coworking dynamic is entirely dependent on the team's harmony, so the team comes here because they want to learn. Therefore, the formation of this culture occurs naturally. Everybody intends to socialize in the area. There is no problem within the team. *Participant 5, Employee, Participant 9*

Having the same goal and the same level of curiosity to make, strengthen social relations. This social subgroup collaborates in the scope of sharing facilities, solving local problems, and online support.

#### 4.4.1.1 Tools for Community Use

Since accessibility of fabrication facilities is not easy due to high prices, makerspaces may have difficulties in their projects. People who have the required physical equipment in the community, support other community members by sharing the tools. With these environments and facilities provided, the activities of the maker groups are maintained in a collaborative manner. Members of the distributed makerspaces need fabrication tools and these requirements are met by the community members. For example, one of the members of Case 2 has a small atelier for their individual use. When there is a need for equipment, members solve the problem within the community.

> The printing volunteers were providing that part. We could take measurements there. We could scale. We could carry out the assembly process there because our material was there. *Participant 2, Member, Industrial Design Engineering*

While there is a sharing environment in the community, it is seen that different maker communities share their facilities with each other. Some of the interviewees state that there are 3D printers companies that give free printing services or some companies donate their machines for use in the makerspace. Therefore, it is seen that there are strong relations among maker communities too. For example, one of the interviewees illustrates their use of facilities in “fellow” companies.

> We have partner machine shops. When something needs to be machined from metal or CNC, we go to their workplace and we can do everything needed there. *Participant 9, Founder, Mechanical Engineering*

Members use the facilities both within the community or outer network. Also, there is a strong feeling of embracing the makerspace. They spend time in the makerspace and it follows a process of founding a tie with the space. One of the interviewees points out their feelings while working in the space.

> Since we do most of our own work there, we spend most of our time there. It doesn't feel like work when someone asks you for a job. I complete it when I see something missing, someone doesn't have to say anything. It's a home-like environment. You embrace it. For example, you're upset because the pliers are broken because they're yours. It is a home-like environment. *Participant 5, Employee, Electrical and Electronics Engineering*

These show that members feel themselves in a maker community and feel responsible while using the facilities. Some of the makers share their customization of work desks since they spend too much time there. They also mention that they prefer to repair the broken products. Also, they make projects to gain new facilities for the community. For example, one of the interviewees mentioned how they meet the community's vacuum forming machine requirements:

> For example, we are now working on a project for baking cookies while creating their own patterns. And they make their own chocolate designs entirely. We make trials. For example, in order to make this workshop, we made a vacuum forming device ourselves. We couldn't buy it from outside, since we don’t have that budget. There is a vacuum system available in the CNC machine and I also brought my oven. Using these, we set up a wooden assembly and tried a lot of PP types, and then we found one type to use as a mold. *Participant 7, Manager, Industrial Design*

With a productive perspective opposed to consumption, they prioritize gaining new facilities for the community. This is possible with the belongingness to the maker community.

#### 4.4.1.2 Collaboration for Local Problems

Rather than responding to individual production facilities or workshops, makerspace has an important role in local problems too. While Cases 2 and 3 are social utility aimed makerspaces, Case 1 and 4 also carry out projects that provide a social benefit. Maker communities launch projects in order to respond to local problems. One of the participants mentions the use of 3d printers while producing face shield movement for the medical staff during Covid-19.

> The face shield thing is a big deal (Covid-19). We directly volunteered for this job. There is Participant 6. Participant 6 tried to print. He went there and dealt with the design. Participant 7 dealt with the coordination. I also worked in the shipping process. There were also supporters who made their prints in their homes. It is a lovely thing that people also work in this area. Since we are already a member of a platform called [a social enterprise], we contacted them. We made nearly 1000 prints. This is an excellent thing. We were able to help people who are working in the field of health and help the doctors. We also helped the security guards in the school. *Participant 5, Employee, Electrical and Electronics Engineering*

With the community perspective, collaborative action through such issues spreads and shows its outcome. Facilities in the space and member's efforts make a collective contribution to the people in need. Around a platform that unites the maker community, they serve social needs collaboratively. Also, maker communities enlarge with a participatory perspective to solve local problems with the local people. One of the members of Case 3 mentions how they include locals in a repairing project for their neighborhood.

> We ran a project specific to the neighborhoods in Kadıköy. We came together, made a list of all the problems we could work on, and started to eliminate them. A few ideas were left. There was painting the trash cans, collecting the waste oil cans, and something else, but I can't remember. The

> easiest thing you could do was paint the trash cans, and it made sense. Why is the garbage can on our streets so dirty? Can we at least keep it clean? For example, you do not want to bring your child closer to the garbage can; you do not let him touch it. This is a bug. Then, we decided to conduct the project around Kadıköy-Fenerbahçe or Bağdat Street. Because we chose the neighborhood since people who participated in the project were living in that neighborhood. *Participant 10, Founder, Mechanical Engineering*

As indicated above, maker culture spread in a collaborative manner through participatory design. With the widespread maker culture, the community generates new collaborative projects in order to improve the local. For example, there is a project called "Free Little Library" which has applications in maker communities abroad. One of the members of Case 3 introduces this project and they make open calls to design an open library in Kadıköy. These are examples of how the maker communities make contributions to the public.

> For instance, there is a community called the Little Free Library in the United States, which encourages people to build street libraries on their doorstep. A volunteer who saw him sent us an e-mail, and we liked it very much. I also made an open call. Lots of people we do not know, probably around twenty people, came to design a street library in Kadıköy. *Participant 10, Founder, Mechanical Engineering*

As given above, there is a reflection of maker culture on people with the social utility aimed project carried out in the community. They respond to societal needs with their abilities to solve problems with their mindset and generate tangible solutions with their facilities.

#### 4.4.1.3 Online Coordination

Maker communities give importance to improving themselves and share their experiences within the community. While space and events are held to create a platform to learn and share, there are alternative ways with the emergent use of the internet. There are online tools that enable coordination and knowledge sharing.

Makerspaces develop their community using online platforms. In order to establish coordination among makers, online tools are mostly used. There are various tools used by the participants; Whatsapp, Facebook, Trello, Mail Groups. Interviewees point out the importance of their use while following a design project. Most of the participants state that online tools are practical for them to coordinate along with the long project duration:

> Communication is usually verbal, but if the process takes a long time in the team, they typically establish a WhatsApp group or set up a mail group for communication among themselves. That way, they all work together. *Participant 5, Employee, Electrical and Electronics Engineering*

These platforms are actively used to share knowledge among participants too. Apart from being informed about the process, it is observed that there is a knowledge transfer among new makers and experts while remote working via these online communication tools.

> We are establishing a WhatsApp group for communication with those volunteers. In this group, the person who is an assembly volunteer can learn what to do by writing to the group and asking questions when they have a problem. For example, she calls me, and asks; "I could not insert this pin, how can I attach it." or "how can we shape that here?" They might ask questions like, where is the matching part of this? *Participant 2, Member, Industrial Design Engineering*

Although knowledge sharing within the community is given above related to the messaging tools, there are other online tools to reach the required knowledge. These online platforms help to spread their community knowledge too. Experts in the maker community become accessible with these platforms. One of the interviewees states that their network enables finding rapid solutions:

> When you send the photo to the group, someone knows it. Guys, we did this yesterday; the cable got stuck on it; does anyone know that? Immediately someone writes, they find the solution. There is also a guy working at Microsoft. There is a hacker; for example, this person gives the best-selling training on Udemy. He's with us too. Everybody gives their support to solve that problem. For example, there is a maker Mark, who has a YouTube channel called ArdunioMack. When someone is stuck, ask questions to him

> and get an answer from there. *Participant 9, Founder, Mechanical Engineering*

The use of these tools raises the awareness of capabilities in that community. Within these communication groups, they get to know each other's interest areas and create social ties while helping each other. For example, one of the members who have a design project that includes coding meets with another member who is an expert in that field. That enables the interaction of different fields with mutual assistance. Also, these people create content for online platforms that everyone can reach.

### 4.4.2 Matching Makers to Collaborate

Makerspaces enable their members to match with someone to carry out projects together. Within the space, it is possible to create social ties with members from different fields. Makers who have experienced working collaboratively create their teams within the community. These social ties reflect on future professional enterprises. One of the participants mention how space-makers guide them to find other makers working in relevant fields:

> We have students contacting us: I have a small network and have difficulties with this topic. We ask the community, "Does anyone want to learn something about this issue and come and support us?" For example, we say either "We have a friend who is dealing with this resin business and need someone while... For example, mold works, he makes a lot of molds. You can learn from him." and we met them. *Participant 7, Manager, Industrial Design*

Since members of the community have diverse interests related to production, it enables makers to find the required help within the community. This is possible both spending time in the space or through networks. Following the social ties formed among makerspace participants, it is seen that makerspace leads to further projects even enterprises.

> For example, the friends in the design team we set up for the Kalamış Park project later applied to the Urban Furniture competition of the IBB and became the winner. For example, there was Benedict and Jonas there. They

> are architects and interior designers. There was also industrial designer Henry. Benedict, Jonas and Henry have never met before. Later, we brought them together for that project. Then they met and decided to prepare for the competition. Because they are an excellent team and there are many examples like this; we met at your meeting, and now we are doing business together. *Participant 10, Founder, Mechanical Engineering*

It is emphasized that there is a strong effect of space-makers on gathering people together to work collaboratively on a project. It is also possible to see these interactions among the members who have the same problems. When they experience an issue related to prototyping, there is someone else who has experienced it before. One of the interviewees mention how they solve a printing problem with collective sharing:

> Yes, they can learn through word of mouth as well, for example, the most obvious example let me tell you, When architecture and industrial design students come here first, their 3D models were so bad for 3D printing. We could not print them or the result was so bad. Then, we tell him the reason for his mistakes. In time, they started to learn how to prepare models. Asking each other how they should make the model, they all improve themselves. With the help of word of mouth, the possibility of the wrong model to print has decreased from 80 percent to around 15 percent. *Participant 6, Employee, Mechanical Engineering*

Within the space, or around a 3d printer, they find a chance to overcome a problem with the collaborative action. There are also situations where space-makers guide them to get feedback from other members.

> For example, I learned a lot, especially from Lady Participant 7. Because I don't know much about design. We usually do ugly things. If it works, it is alright. Will it move, yes. Will it be fixed? I'm usually in this logic, so we can't think about the design part too much. I ask Participant 7 and Participant 12. It's good, isn't it? I've done it a lot in my projects. I consulted a lot to get their opinion when I made that jointed baby. Does it look like marble? Because it was smooth. *Participant 11, Member, Mechanical Engineering*

In these cases, the participant realizes her deficiency and finds people who can help with their expertise. Social ties and proximity in the space enable makers to learn about other members' interests and abilities. In this way, meeting with the correct member to collaborate is possible in this social framework.

### 4.4.3 Social Support to Make

Makerspaces include facilities to enable making activities. Apart from these facilities, there is social support that enhances learning and sharing within the community. While members attend activities more focused on aim, space-makers put effort into spreading maker culture. They believe that the act of making can be transferred by giving people the courage to widen their knowledge. One of the space-makers mention how they transfer their spirit to enlarge this culture:

> Everything that comes there is done to teach other people, to carry the spirit of the maker at the same time. We have our own projects, and we reflect our own projects to other people. So there's a community. Let's have a workshop in order to help people learn, produce, there's no need to buy everything from the outside. *Participant 8, Member, Electrical and Electronics Engineering*

As they make contributions to others, this movement becomes scaleable. Also, there is a perspective that prioritizes the sustainability of the community with transferring experiences to newcomers. Participant 6 (Employee, Mechanical Engineering) states that they try to sustain the collective knowledge in the community through enabling the sharing environment.

## 4.5 Drivers of the Makerspaces

Throughout this study, four different makerspace are analyzed to understand the collaboration characteristics in these areas. However, it is recognized that these spaces have differences in their inherent characters. Mainly, these spaces can be divided into two categories; goal-driven spaces and place-driven spaces. While studying these groups their motivations, structure, and use of space have differentiating aspects. Also, members of the makerspaces make a comparison over their previous experiences to draw attention to how makerspaces differ from business-oriented working environments.

### 4.5.1 Goal-driven Makerspaces

It is observed that some of the makerspaces position their community and goals over the organizational and spatial facilities provided in the makerspaces. Although they relate themselves with the production and have facilities, there is a social aim at the core. In this framework, Case 2 and 3 will be analyzed through their motivation, communal structure, and flexible use of space. Case 2 is a maker community that aims to give prosthetic hands to children. Although they are creating an end product, there are other activities carried to support this disadvantaged group. While some of the members have previous experiences in voluntary organizations, some receive this perspective after being involved in projects. One of the interviewees tells about change in his perspective:

> Actually, truth be told, this was my first volunteer experience while participating in, I already thought that I'll be an engineer. There are mechanical systems and 3D printers here and that would be a plus for my career development. When I first joined I didn't feel like there is social utility here. Then, I recognized that helping people have precedence over technical experience. *Participant 4, Member, Mechanical Engineering*

While he positioned space as a place where technical knowledge can be obtained, this approach shifted to a social framework. Rather than a motivation for personal improvement, it becomes a motivation to have a social impact. Therefore, the common goal of the community gather people together with a strong attachment as indicated below:

> Everyone has the same purpose and people coming together with the same purpose resemble each other. Therefore, it is easy to become friends. Common goals tie us together. *Participant 3, Member, Business Management*

It is stated that there is a familiarity between members caring about the shared goal. When they come up with a shared goal, they don’t present any conflicts. They avoid conflicting with giving precedence to their collective goal. Goal-driven makerspaces attach importance to the communal structure. Projects carried out in these spaces require teamwork rather than personal effort. While people use the space for their individual tasks in other cases, members of the goal-driven spaces perform their tasks within a team. One of the interviewees who experienced a project alone due to time limitations share her feelings as below:

> For example, we did a project with an association out of town. They took the measurement and sent it to us. Since the process was urgent, I worked by myself. Following printing and assembly, it was over. Then, they send the video of the child using that prosthetic arm. I was so happy but there was nobody to share it with. There was nobody to tell how beautiful it looked. So, it is better to work together when you share the goodness and help. No matter if you can do it by yourself, the process becomes more valuable when you share it. *Participant 10, Founder, Mechanical Engineering*

While members tend to act for the shared aim of the community, there is also a communal structure in the organization that does not contain any hierarchy. Since there is no concern about statues, members of the makerspaces work to make the process effective. Roles and responsibilities are more shared considering everyone's motivation to take part. One of the interviewees mention how they generate a system to enhance the progress:

> When I started volunteering, there was no difference among members. [The community manager of Case 2] was taking a little more responsibility training with support from other volunteers. But her load was too much. She was the coordinator of members and cases. Also, she was arranging events and training. And we decided to try a new system in Ankara. There were 15 people who worked as coordinators. These people became responsible for each case to make coordination required for that specific project. It was a facilitator rather than a superior-subordinate relationship. *Participant 1, Member, Electrical and Electronics Engineering*

These organizations maintain their activities with the motivation of their members. It is common to see a person who takes initiative to sustain the community. Their willingness to sustain the community is transformed to other members with a collective perspective. They want to ease the workload on the community manager, by founding a support team. It is not a hierarchical structure under community manager, it is more facilitator of the community activities. Besides, it is seen that there are people who have credence in the community when there is a topic to make a decision. This situation is explained by one of the interviewees as below:

> When someone gives a training, people think that he/she is an expert in the field. It is not a status difference. Maybe he/she spent more time in the field and had more experience. We are taking more responsibility as the facilitators of the community, so it is not an organizational hierarchy. *Participant 2, Member, Industrial Design Engineering*

People who have more experience in the community take roles in training or events. The high responsibility of these members is welcomed as the source of knowledge. Rather than an organizational hierarchy, this situation introduces a communal hierarchy where members who attend more are valued more.

Also, it is observed how the use of space in goal-driven makerspaces changes. Since there is a collective goal rather than personal use of space, goal-driven makerspaces do not position the space and its facilities at the core. It is more important to spread the collective aim in the community. Therefore, they use distributed spaces to carry out their projects.

> We don't have a place where we gather all the time. Actually, there are dwellings that we use. There's no direct Case 3 address. But here, for example, [a 3D printer company] in Istanbul is an area that we can use for the meetings. [an incubation center], [a co-working space] provide us space support, especially in our projects. There are different places we use, according to our needs. For example, something should be produced with 3D printers, and we will make a 3D modelling, we will make prototypes, we go to [a 3D printer company], we work with them. We're acting on what we need. *Participant 10, Founder, Mechanical Engineering*

As indicated above, they use different places for their different tasks. Since they have strong community relations, it is possible to find a place to carry out their activities. It is also similar in Case 2 because they decide their meeting place according to their activity. For example, when they plan to use 3d printers, they prefer to use one of the members' ateliers. It is easy to perform their task when they have the necessary equipment there without any time limitations. Also, there is no restriction while using the equipment since there is no restriction to try something out. This flexibility in space use makes them focused on their goal.

### 4.5.2 Place-driven Makerspaces

Place-driven spaces can be described as areas that give precedence to the organization and its facilities. These places provide facilities to the members of the area with their structured organization. In this framework, Case 1 and 4 will be analyzed through their personal use, structured organization, and use of facilities provided. Place-driven makerspaces contain various opportunities for their members' growth. For example, Case 4, has long terms projects to have experiences like an internship. Also, there are projects funded by the makerspace and they invite people to join and gain experiences. There is a similar opportunity in Case 1 too. They have facilities for personal use and organization that support the members in their activities. One of the interviewees points out how space-makers support their use:

> She's got a graduation project, she is saying how can I achieve this task, and we're offering ideas. We help her using machines, we're helping her while prototyping. *Participant 7, Manager, Industrial Design*

In the context of place-driven spaces, it is commonly seen that members meet with the space for their personal needs like their graduation project or making a present for someone. These spaces provide various opportunities with production equipment and a team that help them while using these:

> Here we have 3D printers, we have laser cutters, we have a lot of equipment, and students come to us when they need something. They come with 3D models or drawings for laser cutting. We help them, we print with 3D printers, we help them with laser cutting. If they have soldering jobs, we have tools to help them. *Participant 6, Employee, Mechanical Engineering*

As interviewees emphasized, there is a variety of equipment in the space. While these facilities become the main use of space, there is also a maker culture spread through the organizational effort. Although members come to the space with a personal aim, makerspace facilitators aim to enlarge the community that learns in this area. One of the facilitators shares his opinion about their organizational aim:

> Everything that is conducted there is done to teach other people, to do something, to carry the spirit of the maker at the same time. We have our own projects, and we reflect our own projects to other people. So there's a community. Let's build a workshop so people can learn, produce, there's no need to buy everything from the outside. *Participant 8, Member, Electrical and Electronics Engineering*

Since place-driven spaces have a dedicated space and various facilities, there is a need for an organizational structure to manage the community. While members of goal-driven spaces emphasize that there are shared responsibilities rather than titles, in place-driven spaces, it is seen that there is a certain definition of makerspace manager. There are also paid personnel that perform activities like preparing training materials, conducting workshops, or being responsible for the machinery. Then, we have the members who benefit from that environment. Also, there are part-time employees who are active members supporting the paid personnel in their tasks. One of the interviewees explain the organizational structure as below:

> I have a manager and a teammate. We work together on tasks. There are also part-time students who support us. *Participant 5, Employee, Electrical and Electronics Engineering*

Within this organizational structure, there are divisions of roles concerning their expertise. However, it is possible to see that there are shifts in roles since they have different fields of interest. Although facilitators in the space have close interaction and cooperation, the reflection of this organizational structure on members of the makerspace is different:

> Sometimes they are afraid to ask [Participant 7] or to ask [Participant 6]. Because they can get nervous and think that I don't know anything. Then they ask the people who work voluntarily, for example, me. Because they see them for their age. We answer about things we know, and when we direct them about things we don't know, they go and ask. Because some of them have no idea, no idea how to move forward. They consult, and they think more about what they understand alone. Then they ask again, for further information.

> More jobs fall on these office workers. *Participant 11, Member, Mechanical Engineering*

Due to the structured organization and strong character of the manager, there is a flattened structure between space-makers and members but not the same for the manager. Since these paid personnel and part-time employees are new graduates or students, it seems easy to interact.

Structured organization and facilities in place-driven spaces enable making activities like training or workshops. While there are goal-oriented specific pieces of training in goal-driven spaces, place-driven spaces hold various events in different fields. This is more related to their resources both in equipment and trainee. For example, one of the members who has knowledge about post-processing 3d printed parts arranged a workshop to transform her experience with the facilities in the makerspace. These activities aim for university members who want to gain different skills. One of the interviewees mention how various events can be done with their resources:

> We organize training in the school, for example, for students who want a 3D design workshop. There's a schedule we've set. We teach students how to make 3D designs. Or we do an electronic prototyping workshop. Everyone comes, draws the circuit, and produces it. Apart from that, for example, we do a lesson about how to use a 3D printer, or we do a lesson about how to use a laser cutter. In addition, Lady Participant 7 does a lesson in design thinking. *Participant 6, Employee, Mechanical Engineering*

Although there are various opportunities, the use of equipment is more restricted in place-driven makerspaces. Having equipment like a jigsaw machine or CNC brings safety requirements in the area. Members of the area cannot use this equipment and they can ask help from space-makers to perform their task with this equipment. While goal-driven makerspaces contain limited and basic equipment, place-driven spaces contain expensive tools and materials that should be used carefully. One of the interviewees explain the precautions while using a milling machine:

> Some tools are very dangerous. For example, only Participant 6 can use the milling machine. Although I took a lesson about milling machines, I cannot

> use them either. They don't let anyone use it. Because it is already throwing a lot of chips out, it can hurt someone else, the tip may break off. You have to stay there wearing protective glasses. *Participant 11, Member, Mechanical Engineering*

Also, there are time limitations while using the area. Since there should be someone to observe members and provide the safety requirements in the space, it is necessary to work within certain time limits. Even there are members who want ta spend more time in the space, it is difficult because of the responsibilities of space-makers:

> We have students who ask why you are closed on the weekend or something like that. So, we have to close, and we actually have a lot of students passing by. *Participant 6, Employee, Mechanical Engineering*

Therefore, the use of place-driven makerspaces is constrained due to time limitations and safety requirements. Also, it is seen that active members of the space may stretch the rules after taking permission from the manager. They may use the area for a weekend project in company with a space-maker or they can try some equipment with the assistance.

### 4.5.3 Comparison of Collaboration Characteristics between Makerspaces and Previous Experiences

Makerspaces present different collaboration characteristics compared to previous experiences of the interviewees in business-oriented working environments. There are members who have experienced full-time jobs in corporate firms, start-up environments, and internships. Giving examples from their internships or work experiences, they compare both working frames in terms of collaborative work. Most of the participants emphasize the distinct characters in makerspaces such as disciplinary independent working environment, enabled collaboration, and encouraged productivity.

#### 4.5.3.1 Blurred Disciplinary Borders

Makerspaces have their own non-disciplinary working environment rather than separate departments. In business-oriented working environments, there are departments that specialized in an area. However, makerspaces do not classify their members according to their disciplines. They have more task-related or responsibility-related classifications. One of the makers describes his previous experiences in one of the defense industry firms as being restricted into his disciplinary fields.

> I was in the Electronic communications department in [a defense company]. I had a team manager there; he was defining what we will do. We were also working in that limited area. Everyone has a card, a region. You cannot leave this area. When you are moving away from that area; for example, you cannot talk to another person. *Participant 5, Employee, Electrical and Electronics Engineering*

Since disciplinary borders become obvious with the physical borders in the space, interaction among different disciplines gets difficult. In contrast, makerspaces are independent of these borders. Most of the participants emphasize flexibility in their field of interest. One of the interviewees mentions how he act freely while working on different tasks:

> We have this in maker culture; people usually want an expert in a field, but this is not the case with a maker. There is a culture of learning among makers. By learning, you develop or produce something, so you can inevitably work in every field when you adapt to this culture. I mean, I can go and do the work that a software developer has done. And this is not a problem when someone asks about my profession. I can easily say I am from the electrical-electronics field because you can learn this in Maker culture. *Participant 5, Employee, Electrical and Electronics Engineering*

Transitions between different tasks are possible with the welcoming learning environment. It is important to have the desire to shift to new fields. Maker culture rejects the approach of positioning yourself in a specific area. With their multifaceted personalities, they are open to dive into new fields. Although there is a classification according to tasks and responsibilities in makerspaces, members do not feel any deficiency in the case that they don't have any information. One of the interviewees remarks his comparison of responsibility as below:

> When I meet and work with corporate firms as a white-collar, there is a concept that “this is not in my job” description. We do not have that. We are dealing with everything. The only thing we say is it's not my specialty; I don't know. *Participant 5, Employee, Electrical and Electronics Engineering*

While there is a job definition in corporate firms, makers have a flexible interest area and that is not corresponding to an area of responsibility. Having a flexible area of interest enables makers to interact with other individuals in the space.

#### 4.5.3.2 Enhanced Collaborative Learning Environment

Makerspaces provide a collaborative environment that initiates interaction among participants. There are organizational, spatial, and social elements that ease the interaction as discussed before. Coworking spaces are compared with the makerspace from the perspective of an interviewee:

> When you want to ask a question in a coworking space, you cannot ask. Because the man came there for a different need, to do his work. For example, when I see a person wearing headphones, I don't go and bother in such places. The people here can run everything simultaneously and do not see each other as an obstacle; They are people who came here to have this type of work culture. *Participant 9, Founder, Mechanical Engineering*

Since the interviewee knows that other people have different aims to work in that area, he avoids making contact. On the other hand, makers feel relaxed while asking questions and learning within the community. One of the interviewees makes a comparison between makerspace and university laboratories as follow:

> All of the people who come there are from different departments: Electrical-electronics engineer, computer engineer, mechanical engineer, etc. There are programs and software used by each of them in their field. A structure was established to help every person who comes into Case 1. Whether an architect or an engineer comes, there are people in every area to help. Someone who comes to space can do whatever he wants. In this way, communication is established. For example, when I say that I will do a project, it has to

> withstand absolute pressure, and it should be aesthetically pleasing; an architect friend comes, draws it, or Participant 6 does his 3D design there. There is a more severe structure in the other laboratory, everyone is doing their job there, so there is no such environment. This environment provides better learning opportunities. For example, I am a student of electrical and electronics engineering, but using Fusion360. I have learned this. *Participant 8, Member, Electrical and Electronics Engineering*

As given above quotations, makerspaces give the opportunity to interact with other members. There are people who are open to help and discuss the environment. This interaction is seen as valuable compared to other working frames that people focus on their tasks.

#### 4.5.3.3 Encouraged Productivity

Makerspaces differentiate from business-oriented working environments with their closeness and rapidness in production. While business-oriented working environments have economical precedence, it makes it difficult to make iterations. Also, it is difficult to reach production due to organizational structure. While some of the firms have restrictions on using machines due to safety considerations, some have long approval processes in organizational structure. Participant 12 (Part-Time Employee, Industrial Design) emphasizes the openness to make trials in makerspaces contrary to corporate firms from her experiences during the internship.

Makers' productivity is directly related to their curiosity even things they are working on seem not possible. Since large scale business-oriented firms use advanced technologies such as CNC machining or plastic molding, making a prototype cost high prices. On the other hand, makerspaces prioritize trial and error as a baseline. With the low-cost manufacturing abilities with 3d printers, laser cutters, etc., it is accessible to have prototypes. Therefore, makers feel encouraged to make iterations without any economic concerns.

> Even if I did something wrong, it could be reversed. For example, I got the wrong print; I did it wrong; I can change it. It brought me a little more courage in that matter. *Participant 4, Member, Mechanical Engineering*

Since makers adopted an iterative approach without any worry, their learning process is enhanced with the encouraged productivity. Compared to business-oriented environments, makerspaces provide an opportunity to enhance the design process with their supportive environment. Participants who meet this culture define themselves as more productive. Involving in the production encourages them to use that knowledge set to apply their life.  One of the interviewees remarks that:

> If something broke at home, I would fix it, but there was no production. Honestly, when someone said 3d printers, I used to say how nice it was, but unnecessarily. After getting introduced to this culture, I even produced a cover for the laptop. Also, I printed a pencil case for myself. *Participant 11, Member, Mechanical Engineering*

Makerspaces introduce participants to the working prototypes. Most of the interviewees state that creating a working product makes them happy and encourages them to be more productive. One of the interviewees from Case 2 describes his happiness after giving a serviceable 3D-printed prosthetic hand to one of the patients. She emphasized that it is possible to see things you created have an effect on someone's life compared to her previous experience.

> In fact, being able to see what I am doing, making something tangible gives very nice help. As I said, it feels very nice for our brother to be holding something after using that hand thanks to something you have done, and to see him living with hope. *Participant 3, Member, Business Management*

Members who are involved in a project that has social benefits are able to see the impact of their products. While working in a business-oriented company, it is difficult to see the impact.

## 4.6 Summary

This chapter has presented the analysis of gathered data from the interviews. The findings of this analysis are divided into five sections.

Firstly, the involvement process experienced in makerspaces is presented. While discussing this process, both approaches of members and space-makers are considered. While newcomers define themselves as people who have multifaceted interests and are productive; space-makers support the involvement process by giving courage. It is also stated that the involvement of members and having a role in the community is a process showing differences. While some of the members are involved with their high participation and dedication, some of them are recruited by space-makers.

Secondly, organizational dimensions of collaboration in makerspaces are presented. It starts with defining the team's dynamics while mentioning role sharing, diversity of disciplines, and non-disciplinarity in makerspaces. Analysis of the gathered data shows that members of the space take roles in the teams with their inclination. Although there is a diverse environment in terms of disciplines, the disciplinarity does not exist. Also, the decision-making process in these environments is carried without any disciplinary or hierarchical statute. It is seen that people share their experiences and opinions to construct common ground. Besides, collaborative learning practices in makerspaces are mentioned by introducing the ways of sharing the knowledge: peer learning, workshops, open-source, and learning through tangible products. It is emphasized that learning occurs with interactions in physical space or online sources. Throughout the learning process, production facilities and prototypes are used effectively.

Another section of this analysis points out the spatial dimensions of collaboration in makerspaces. It is seen that spatial design, physical equipment available in the area, and prototypes made in the makerspaces become means of collaboration. While space provides members with a meeting area, they also encounter and interact with other makers and their projects. Physical equipment and fabrication facilities become hotspots where the interaction is seen mostly. They share their knowledge and experiences via the equipment or prototypes they made.

Another section of this analysis points out the social dimensions of collaboration in makerspaces. It begins with the maker community and its effect on collaboration. Analysis of the interviews shows that there is shared use of tools in the community. Also, members respond to local issues and that becomes the common goal that unites them. Through online communities such as Whatsapp groups, Youtube or Udemy, they reach the source in this network. Within the community, there are people with different capabilities and there is a social environment that brings together and supports them.

Lastly, drivers of the collaboration in makerspaces are presented with a comparative approach. Research cases are grouped into two considering the ways of using the space: goal-driven and place-driven. Goal-driven makerspaces gather people who want to contribute to the collective goal, in this context it is a social benefit. On the other hand, place-driven makerspaces provide an environment for personal aims. It is observed that goal-driven makerspaces prioritize the community. Members and space-makers of the goal-driven makerspaces have the motivation to sustain the community. As opposed to goal-driven makerspaces, place-driven makerspaces are more organization-oriented with their structured hierarchy and defined responsibilities in the space. In terms of using space, goal-driven makerspaces use distributed areas to carry out their tasks. However, place-driven makerspaces have a dedicated area where various fabrication tools exist. The use of space is more flexible in goal-driven makerspaces since place-driven makerspaces have organization rules in terms of time and safety.

# CHAPTER 5

# CONCLUSION

In this chapter, the conclusions of this research are presented in detail. It begins with an overview of the study. Then, the main conclusions deduced from the analysis chapter are discussed in consideration of the existing literature. Lastly, the limitations of the study and recommendations for further research are explained.

## 5.1 Overview of the Study

This study aims to reveal how collaborative activity takes place in makerspaces within their organizational, spatial and social context. In line with this aim, the experiences of members who are from different communities; university makerspaces and public makerspaces for the social benefit, are investigated.

To provide a basis for the study, firstly, the related studies in the literature were reviewed. The review focused on two bodies of literature: collaboration and the Maker Movement. Through the collaboration literature, disciplinary frameworks were discussed by introducing disciplinarity, multidisciplinary, interdisciplinary, and transdisciplinary collaboration. After that, collaboration in business-oriented working frameworks was examined in terms of organizational, spatial, and social dimensions. Secondly, the emergence of the maker movement and its disciplinarity were presented. Similarly, collaboration characteristics in these emergent work ecosystems were discussed considering their organizational, spatial, and social elements.

To fulfil the aim of the study, the research approach and the sampling strategy were determined. Then data collection was described with the techniques used and process of conducting interviews. Finally, the data analysis was presented by introducing the template analysis method and its iterative application process.

Followingly, the analysis of the study was presented under three main headings. Firstly, the involvement process of both members and space-makers in the community was described. Then, collaboration characteristics in makerspaces were investigated considering their organizational, spatial, and social dimensions. Lastly, drivers of collaboration were categorized as place-driven and goal-driven regarding changing use of makerspaces in different contexts. These drivers were also compared with the previous work experiences of the participants to clarify the differentiating characteristics of makerspaces.

## 5.2 Main Conclusions

This thesis draws three main conclusions regarding research questions, based on the analysis of the gathered data. The literature review has revealed that there is a limited number of studies that investigate forms and characteristics of collaboration in makerspaces comprehensively. Current literature discusses the organizational structure through presenting hierarchical orders and involvement to the community. However, the motivations and processes for getting involved in makerspaces and the community around them have not been clarified. Some studies also focused on the necessary equipment for and spatial design of the makerspaces without questioning their effect on collaborative activity. Although there is a strong emphasis on the importance of community, its effect on collaboration is not sufficiently explored. This indicates the importance of understanding the experiences of both makerspace members and facilitators within a collaboration context. Also, examining the experiences of participants with a comparative approach will introduce the distinctive characteristics of collaboration. As such, the research questions for this study are as follows:

1. How and to what extent do the collaboration characteristics change in relation to the particular elements of makerspaces?
2. What are the effects of organizational, spatial, and social elements of makerspaces on collaborative activities through the thoughts and experiences of makerspace members?
3. How and to what extent does the collaboration among participants differ in changing makerspace contexts?

In order to answer these questions, interviews were conducted with 12 people from different maker communities. Based on the analysis of these interviews, this thesis draws three main conclusions:

1. Although makerspaces gather people from various disciplines together, they exist as **knowledge professionals with their interest-driven knowledge** rather than disciplinary knowledge. Therefore, **the disciplinary concept and its borders are blurred in makerspaces** with the prominent maker personality.
2. Both eagerness to make and making-oriented space position the act of making at the core. Makers learn through making and interact through the tangible means that they made. This **practice-oriented community harbors knowledge within its physical and online environment** while disseminating maker culture.
3. Makerspaces take different forms in their varying fields of applications. Within these different contexts, drivers of the collaboration change as **place-driven** or **goal-driven**. While some communities gather around a common goal that enables a sustained community with its flattened organization, some communities have the place at the core which enables the personal development of its members with a sustained organization.

These prominent conclusions will be argued separately associated with discussions in existing literature in detail.

### 5.2.1 Non-Disciplinarity in Makerspaces

Analysis of the gathered data revealed that collaboration among participants occurs independently from the disciplinary identities. Analyzing their process of involvement in the community, it is obvious that their interest and curiosity have precedence over their professional identity. Individuals in these spaces tend to become multi-faceted with the diversity in the space. The diverse disciplinary nature of these places is seen as an opportunity to develop different perspectives. Within this diversified environment, individuals exhibit their knowledge areas. While they take a role in the team, it is more seen that their interest and motivations drive the role sharing. Apart from some specific situations require expertise (i.e. opinions of doctors and physiotherapists in Case 2 about the necessity of prosthesis arm), it can be said that disciplinary concerns are not significant and their disciplinary identities are blurred during the design process. While making a decision, previous experiences and knowledge related to the topic drive the decision process rather than disciplinary knowledge. Also, the analysis chapter presents that within this community, the experiences of members are matched with each other to form teams regardless of disciplinary identities.

The reviewed literature classifies disciplinary frameworks of collaboration that explain the level of interaction. There are arguments on framing the disciplinarity in makerspaces but these arguments are more focused on the diversity in disciplines not the way they interact with each other. Analysis of the interviews supports the definition of ‘discipline-neutral informal learning spaces’ (Mathuews & Harper, 2018, p.359) where “making erases disciplinary boundaries... or transcends them” (Byrne & Davidson, 2015, p.10).

While Gibbons et al. (1994) explained the production of knowledge, they categorized it in two: Mode 1 and Mode 2. While Mode 1 is focused on disciplinary knowledge, Mode 2 is more application-oriented. Considering the gathered data, makerspaces have the environment that enables practicing. Van den Besselaar (2001) introduced the term *non-disciplinarity* as being more *application-oriented*. Also, Maton (2002) states that *non-disciplinarity* weakens academic hierarchies and boundaries among disciplines. It blurs out the differences in teacher-trainee, between high-low culture, and between academic-practical knowledge through freeing knowledge from enclosed fields.

Within this discipline-neutral environment, role sharing occurs according to members' interests. The participants tend to explain their motivation independent from their disciplinary background. Edelson and Joseph (2004) describe this as interest-driven learning and it can be framed as content-based or context-based motivation. While content-based motivation stands for personal interest in a specific topic, object, and activity; context-based motivation comes from a reward motivation or social sense of achievement. It can be concluded from the analysis that there are personal and social benefit-oriented aims supporting this literature.

This conclusion is drawn while investigating particular elements of makerspaces as probed in the research questions. It is seen that makerspaces bring various disciplines and interest areas together that triggers the diversified environment. However, this diverse environment is not directly related to specific disciplines; it is more related to the practice-based nature of makerspaces. It is also inferred that makers work together with their complementary knowledge and skills while investigating organizational and social characteristics of makerspaces as probed in research questions.

### 5.2.2 Learning and Sharing Knowledge through Making

As seen in the analysis chapter, participants have a perspective that prioritizes the making. They are familiar with the maker culture since they have previous hobbies or community relations. They tend to make their own products and be close to the places where the production is performed. That brings them to the makerspaces where making tangible things is the core activity. These places have the agility of making with the facilities provided. Also, there is an environment that encourages making without any concern for failure. Members want to make iterations and facilitators support this act. Within these making-oriented spaces, learning occurs over tangible means. There are workshops held in the space that use fabrication tools effectively. Workshops have the opportunity to experience materials, equipment, and processes to digest knowledge in the space. Also, the use of space enables members to encounter many different prototypes in the space. Therefore it is a living making environment that encourages active learning. In these living environments, there is a strong interaction among makers. They learn through observing or discussing projects with each other. Through these shared experiences, knowledge disseminates within the practice environment and community knowledge is produced.

In the given literature, Smith (2001) describes the ways of sharing and generating knowledge as tacit and explicit knowledge. While explicit knowledge, *know-what*, refers to academic knowledge that can be distributed with formal language; tacit knowledge, *know-how*, is based on the practice of individuals and can be distributed via perspective, experiences, and abilities. It can be deduced from the analysis, the learning process in makerspaces contains relation with the experienced person rather than an instructor. Participants learn from peers in the makerspace or during workshops where tacit knowledge is transferred. Enabling this interaction is possible with the shared space and equipment used. It is supported in the literature, Keune et al. (2015) emphasize the effects of the accessibility, mobility, and flexibility of tools in the academic makerspaces on collaborative learning. Also, Wardrip et al. (2015) relate the practice-based perspective of makers with their learning process.

Taylor et al. (2016) draw attention to the effect of equipment on initiating interaction among participants. It is observed that both physical equipment and prototypes gather attention and encourage sharing environments over them. Through these means, there is an active production of knowledge and its circulation both within the community and among communities. Supporting this evidence, Artut (2018) points out how makers become active producers of community knowledge via produced means.

It is concluded that learning and sharing activities show main differences with the particular characteristics of makerspaces. Maker mindset and making-oriented environment can be introduced as particular characteristics of makerspaces as probed in the research question. The inclination to make and the experimental approach of makers are inferences regarding this research question. It is also stated that learning and sharing activities are enhanced with the making oriented creation environment. While investigating the learning practices, it is also answered how maker organizations manage the learning environment. Apart from the organizational approach to learning and sharing the practice of making, there are also spatial and social phenomena that are probed in the research questions. In this spatial and social infrastructure, they interact with each other and the surrounding elements to generate and disseminate knowledge through making activities.

### 5.2.3 Drivers of the Collaboration in Makerspaces

In the scope of this study, interviews are carried out with people from 4 different makerspaces. The analysis revealed the effects of the differentiating features of these spaces on collaborative action. While some of them have a structured organization in a dedicated space, some use distributed spaces with a strong sense of community. These varying characteristics of makerspaces can be grouped as **place-driven** and **goal-driven** makerspaces. Within this categorization, it is possible to observe how collaboration differentiates in different contexts. In place-driven makerspaces, attendance to the community is more associated with space and its facilities used by individuals. They aim to carry out their individual or group tasks in the provided environment. On the other hand, goal-driven spaces bring people together under the roof of a common goal that prioritizes social benefit. Therefore, the motivations of participants differ at this point. Also, there are organizational differences in the hierarchical structure. While place-driven makerspaces have responsibilities to maintain a shared environment with their facilities and personnel. These responsibilities require a hierarchical structure and rules for the space. Opposed to place-driven makerspaces, goal-driven makerspaces give priority to sustain the community. Therefore, there is a flattened structure that gives importance to the collective effort to carry out projects.

Collaborative environments are categorized according to their openness and hierarchical structure (Salonen, 2012). Considering the provided frame in literature, goal-driven makerspaces differ from place-driven makerspaces with their hierarchical structure. As seen in the analysis, there is a decentralized decision-making process in goal-driven spaces. It can be deduced that flattened organizational structure enhances interaction among members. Also, Dougherty (2016) introduces the pyramid of participation in the community which defines the levels of participation. While this hierarchical structure is observed in place-driven makerspaces as members, part-time employees, and makerspace facilitators; goal-driven makerspaces follow a different process of involvement that is parallel to the sense of belonging. McMillan and Chavis (1986) state the importance of the sense of belonging on having a shared understanding, attending the discussion environment, and having the motivation to contribute to the community members. This also supports the results that goal-driven makerspaces give importance to sustain the community with a collective perspective.

In the scope of this study, four different makerspaces that carry out activities in different fields were investigated and their differences were probed. While making the classification of place-driven and goal-driven makerspaces, it can be seen that there are motivational, organizational, spatial and social differences. Therefore this conclusion covers all the research questions and draws a general picture of collaboration in makerspaces within differentiating elements.

In the light of these drawn conclusions, this study presents a comprehensive analysis of how makerspaces should be managed from the perspective of design practice. It provides guidance to the space-makers while forming a social and sustainable making environment. Significantly, the organizational structure of makerspaces determines the level of social links and sustainability of communities in terms of their participants. Also, the nature of making-oriented spaces enables participants to interact with each other over tangible means, experiences, and knowledge. Within these considerations, the sustainability and scalability of makerspaces can be enhanced with the efforts of space-makers.

This study also puts forward guidance for other coworking settings. Even though it make inferences in the context of academic makerspaces, social enterprises, and non-profit maker organizations, these conclusions can be adapted to other coworking environments. It may serve as guidance for community managers about how making activities can be integrated into coworking areas and how interactions and learning environments can be enhanced with these elements. The making-oriented approach of makers introduced in this study may enhance the growth of enterprises in coworking spaces with agile and tangible outputs.

Lastly, there may be implications to design education and professional practice. Designers as multifaced professionals should integrate their practice-based design education given in the studios to a more collaborative frame. The scope of design education in studio classes could be enhanced with the collaborative classes introduced by lecturers with the introduced organizational, spatial and social elements introduced in this study. Also, design professionals working in coworking areas could enhance design processes with their practice-oriented perspective in their creative working settings.

This study was conducted during Covid-19 Pandemic which has affected the ways of how people work with each other. Its impact on coworking areas is significant since these spaces introduce a collaborative working setting. However, makerspaces made an effort to maintain their activities as deducted from the interviews. Supporting the idea of this conclusion, makers became organized to solve this complex issue with their making-oriented perspective. Although they do not have a chance to come together to make, they made individual contributions to a collective movement of face shields with printing activities. With the community-driven approach, they shared both facilities and knowledge to generate solutions. It is also seen that makers are not strictly dependent on a dedicated space to carry out making activities. Their mindset and community approach enable making in distributed areas with the networked members.

## 5.3 Limitations of the Study

The data collection phase of the study was carried out during the Covid-19 pandemic. It was difficult to reach more participants due to pandemic restrictions. The researcher could not find a chance to visit makerspaces to meet people and participants were not using the space either. Therefore, the researcher contacted people via online platforms and that made it difficult to enlarge the sample size. Although it was a limitation, gathered data was rich to make the analysis.

On the other hand, carrying out a research study within a university makerspace required time for permission. Primary meetings were done to discuss the scope and confidentiality to get permission from university management. Also, reaching the members of the makerspace was only possible through the help of the makerspace manager due to ethical considerations about sharing contact information. Therefore, the researcher waited for makerspace members’ responses to the call for participation, and it was a long process to contact the volunteer participants. For other case groups, community managers were helpful while suggesting possible volunteers to study and they shared their network to scale up the research.

## 5.4 Recommendations for Further Research

In the scope of this study, makerspaces in different locations and their structures are analyzed to form a general idea related to collaborative action in makerspaces. As given in section 5.2, there are points that makerspaces differentiate from each other, so their collaborative environment show differences too. Therefore, for future studies, collaborative action can be investigated with a comparative approach over cases from several makerspace contexts.

Another point drawn from this study is the learning environment in the makerspace. Collaborative learning with the programs that are designed using design tools and mindset lead to further studies to handle this topic from an education service design perspective. It is seen that facilitators of the space were working on preparing workshops, and it would be interesting to make an extensive study on their design processes. Such a study might answer the question of how and to what extent the design of educational programs that centralize making enhance collaborative learning.

## REFERENCES


Adams, P. (2006). Exploring social constructivism: Theories and practicalities. *Education*, *34*(3), 243-257.

Adams, W. C. (2015). Conducting semi-structured interviews. *Handbook of practical program evaluation*, *4*, 492-505.

Anderson, C. (2012). *Makers: The new industrial revolution*. Random House.

Arias, E., Eden, H., Fischer, G., Gorman, A., & Scharff, E. (2000). Transcending the individual human mind—creating shared understanding through collaborative design. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *7*(1), 84-113.

Artut, S. (2018). Makerspace or Maker (-): Making Culture as an Alternative Society to Mass Consumption. *International Journal of Social and Economic Sciences*, *8*(2), 52-55.

Baek, J. S., Kim, S., Pahk, Y., & Manzini, E. (2018). A sociotechnical framework for the design of collaborative services. *Design Studies*, *55*, 54-78.

Bailey, P. H., & Tilley, S. (2002). Storytelling and the interpretation of meaning in qualitative research. *Journal of advanced nursing*, *38*(6), 574-583.

Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *The journal of the learning sciences*, *9*(4), 403-436.

Benkler, Y., Shaw, A., & Hill, B. M. (2015). Peer production: A form of collective intelligence. *Handbook of collective intelligence*, *175*.

Braga, M., & Guttmann, G. (2019). The knowledge networks in a makerspace: The topologies of collaboration. *International Journal of Science and Mathematics Education*, *17*(1), 13-30.

Brazdauskaite, G., & Rasimaviciene, D. (2015). Towards the Creative University: Developing a Conceptual Framework for Transdisciplinary Teamwork. *Journal of Creativity and Business Innovation, 1*, 49-63.

Brewerton, P. M., & Millward, L. J. (2001). *Organizational research methods: A guide for students and researchers*. Sage.

Bronstein, L. R. (2003). A model for interdisciplinary collaboration. *Social work, 48*(3), 297-306.

Bucciarelli, L. L. (1988). An ethnographic perspective on engineering design. *Design studies*, *9*(3), 159-168.

Burke, J. J. (2014). *Makerspaces: a practical guide for librarians* (Vol. 8). Rowman & Littlefield.

Burns, M., & Howison, J. (2001). Digital manufacturing–Napster fabbing: Internet delivery of physical products. *Rapid Prototyping Journal*.

Byrne, D., & Davidson, C. (2015). MakeSchools Higher Education Alliance: State of Making Report.

Camburn, B. A., Sng, K. H., Perez, K. B., Otto, K., Wood, K. L., Jensen, D., & Crawford, R. (2015, August). The way makers prototype: principles of DIY design. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 57175, p. V007T06A004). American Society of Mechanical Engineers.

Cannon-Bowers, J. A., & Salas, E. (2001). Reflections on shared cognition. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*, *22*(2), 195-202.

Capdevila, I. (2017). A typology of localized spaces of collaborative innovation. In *Entrepreneurial Neighbourhoods*. Edward Elgar Publishing.

Chan, M. M., & Blikstein, P. (2018). Exploring problem-based learning for middle school design and engineering education in digital fabrication laboratories. *Interdisciplinary Journal of Problem-Based Learning*, *12*(2), 7.

Chaurasia, S. S., Kaul, N., Yadav, B., & Shukla, D. (2020). Open innovation for sustainability through creating shared value-role of knowledge management system, openness and organizational structure. *Journal of Knowledge Management*.

Chen, L., Wang, W., & Huang, B. (2014). A negotiation methodology for multidisciplinary collaborative product design. *Advanced Engineering Informatics*, *28*(4), 469-478.

Ciolfi, L., & Bannon, L. J. (2007). Designing hybrid places: merging interaction design, ubiquitous technologies and geographies of the museum space. *CoDesign*, *3*(3), 159-180.

Claver-Cortés, E., Zaragoza-Sáez, P., & Pertusa-Ortega, E. (2007). Organizational structure features supporting knowledge management processes. *Journal of Knowledge management*.

Collin, A. (2009). Multidisciplinary, interdisciplinary, and transdisciplinary collaboration: Implications for vocational psychology. *International journal for educational and vocational guidance*, *9*(2), 101-110.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Culpepper, M. K., & Gauntlett, D. (2020). Making and learning together: Where the makerspace mindset meets platforms for creativity. *Global Studies of Childhood*, *10*(3), 264-274.

Cummings, J. N., & Kiesler, S. (2008, November). Who collaborates successfully? Prior experience reduces collaboration barriers in distributed interdisciplinary research. In *Proceedings of the 2008 ACM conference on Computer supported cooperative work* (pp. 437-446).

Davee, S., Regalla, L., & Chang, S. (2015). Makerspaces: Highlights of select literature. *The Maker Education Initiative*.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). *The Sage handbook of qualitative research*. sage.

Dixon, C., & Martin, L. (2014). Make to relate: Narratives of, and as, community practice. Boulder, CO: International Society of the Learning Sciences.

Domik, G., & Fischer, G. (2011). Transdisciplinary collaboration and lifelong learning: Fostering and supporting new learning opportunities. In *Rainbow of computer science* (pp. 129-143). Springer, Berlin, Heidelberg.

Dougherty, D. (2012). The maker movement. *Innovations: Technology, governance, globalization*, *7*(3), 11-14.

Dougherty, D. (2013). The maker mindset. In Honey, M., & Kanter, D. E. (Eds.), Design. Make. Play. Growing the next generation of STEM innovators (pp. 7–16). New York, NY: Routledge

Dougherty, D. (2016). *Free to make: How the maker movement is changing our schools, our jobs, and our minds*. North Atlantic Books.

Dousay, T. A. (2017). Defining and differentiating the makerspace. *Educational Technology*, 69-74.

Dykes, T. H., Rodgers, P. A., & Smyth, M. (2009). Towards a new disciplinary framework for contemporary creative design practice. *CoDesign*, *5*(2), 99-116.

Edelson, D. C., & Joseph, D. M. (2004, October). The interest-driven learning design framework: Motivating learning through usefulness. In *Proceedings of the 6th international conference on Learning sciences* (pp. 166-173).

Fiol, C. M. (1994). Consensus, diversity, and learning in organizations. *Organization science*, *5*(3), 403-420.

Fischer, G. (2004, July). Social creativity: turning barriers into opportunities for collaborative design. In *Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices-Volume 1* (pp. 152-161).

Flick, U. (2004). Constructivism. In U. Flick,, E. Kardorff, & I. Steinke (Eds.), A Companion to Qualitative Research. London, UK: Sage Publications.

Foth, M., Lankester, A., & Hughes, H. (2018). Mixhaus: dissolving boundaries with a community makerspace. In *Digital Participation through Social Living Labs* (pp. 97-116). Chandos Publishing.

Gandini, A. (2015). The rise of coworking spaces: A literature review.

Gardner, H., & Gardner, H. (2000). *The disciplined mind: Beyond facts and standardized tests, the K-12 education that every child deserves*. Penguin.

Garvin, D. A. (1993). Building a learning organization. Harvard Business Review, 71 (4).

Gerdenitsch, C., Scheel, T. E., Andorfer, J., & Korunka, C. (2016). Coworking spaces: A source of social support for independent professionals. *Frontiers in psychology*, *7*, 581.

Gershenfeld, N. (2012). How to make almost anything: The digital fabrication revolution. *Foreign Aff.*, *91*, 43.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. sage.

Gibson, M. (2019). Crafting communities of practice: the relationship between " making and learning. *International Journal of Technology and Design Education*, *29*(1), 25-35.

Güler, E., Andersson, A. P., Mirtaheri, P., & Gjøvaag, T. (2017). Makeriet: a Norwegian university makerspace. The Design Society.

Halverson, E. R., & Sheridan, K. (2014). The maker movement in education. *Harvard educational review*, *84*(4), 495-504.

Hatch, M. (2014). *The maker movement manifesto: Rules for innovation in the new world of crafters, hackers, and tinkerers*. New York: McGraw-Hill Education.

Herro, D., Quigley, C., Plank, H., & Abimbade, O. (2021). Understanding students' social interactions during making activities designed to promote computational thinking. The Journal of Educational Research, 114(2), 183-195.

Honey, M., & Kanter, D. E. (Eds.). (2013). *Design, make, play: Growing the next generation of STEM innovators*. Routledge.

Huang, X., Rode, J. C., & Schroeder, R. G. (2011). Organizational structure and continuous improvement and learning: Moderating effects of cultural endorsement of participative leadership. *Journal of International Business Studies*, *42*(9), 1103-1120.

Hynes, M. M., & Hynes, W. J. (2018). If you build it, will they come? Student preferences for Makerspace environments in higher education. *International Journal of Technology and Design Education*, *28*(3), 867-883.

Hyysalo, S., Kohtala, C., Helminen, P., Mäkinen, S., Miettinen, V., & Muurinen, L. (2014). Collaborative futuring with and by makers. *CoDesign*, *10*(3-4), 209-228.

Jakubik, M. (2008). Experiencing collaborative knowledge creation processes. *The learning organization*.

Jantsch, E. (1972). Towards interdisciplinarity and transdisciplinarity in education and innovation. *Interdisciplinarity*.

Jensen, M. B., Semb, C. C. S., Vindal, S., & Steinert, M. (2016). State of the Art of Makerspaces-Success Criteria When Designing Makerspaces for Norwegian Industrial Companies. *Procedia Cirp, 54,* 65-70.

Kokkonen, A., & Vaagaasar, A. L. (2018). Managing collaborative space in multi-partner projects. *Construction Management and Economics*, *36*(2), 83-95.

Kalil, T. (2013). Have fun—learn something, do something, make something. Design, make, play: Growing the next generation of STEM innovators, 12.

Kallio, T. J., Kallio, K. M., & Blomberg, A. J. (2015). Physical space, culture and organisational creativity–a longitudinal study. *Facilities*.

Keune, A., Gomoll, A., & Peppler, K. (2015). Flexibility to learn: Material artifacts in makerspaces. In fifth annual FabLearn Conference: Equity and Diversity in Making. Palo Alto, CA: Stanford University.

King, N. (2004). Using templates in the thematic analysis of text. *Essential guide to qualitative methods in organizational research*, *256*.

Klein, J.T., 2000. Integration, evaluation, and disciplinarity. In: M.A. Sommerville and D.J. Rapport, eds. Transdisciplinarity: Recreating integrated knowledge. Oxford: EOLSS Publishers Co. Ltd., 49–59.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago University press.

Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. Sage.

Kurti, R. S., Kurti, D. L., & Fleming, L. (2014). The philosophy of educational makerspaces part 1 of making an educational makerspace. *Teacher Librarian*, *41*(5), 8.

Leforestier, A. (2009). The co-working space concept. *CINE Term project*.

Levy, P. (1999). Collective intelligence: Mankind's emerging world in cyberspace. Cambridge, MA, USA:Perseu.

Linde, C. (2001). Narrative and social tacit knowledge. *Journal of knowledge management*.

Lindtner, S., Hertz, G. D., & Dourish, P. (2014, April). Emerging sites of HCI innovation: hackerspaces, hardware startups & incubators. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 439-448).

Lloyd, P. (2000). Storytelling and the development of discourse in the engineering design process. *Design studies*, *21*(4), 357-373.

Malone, T. W., & Crowston, K. (1990, September). What is coordination theory and how can it help design cooperative work systems?. In *Proceedings of the 1990 ACM conference on Computer-supported cooperative work* (pp. 357-370).

Maton, K. (2002). Popes, Kings & Cultural Studies: Placing the commitment to non-disciplinarity in historical context. In *Cultural Studies* (pp. 31-53). Brill.

deMarrais, K. B., & Lapan, S. D. (2003). Qualitative interview studies: Learning through experience. In *Foundations for research* (pp. 67-84). Routledge.

Martin, L. (2015). The promise of the maker movement for education. Journal of Pre-College Engineering Education Research (J-PEER), 5(1), 4.

Mathuews, K., & Harper, D. (2018). One size does not fit all: Maintaining relevancy in the modern makerspace movement. *College & Research Libraries News*, *79*(7), 358.

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of community psychology*, *14*(1), 6-23.

Menichinelli, M., Bianchini, M., Carosi, A., & Maffei, S. (2017). MAKERS AS A NEW WORK CONDITION BETWEEN SELF-EMPLOYMENT AND COMMUNITY PEER-PRODUCTION. INSIGHTS FROM A SURVEY ON MAKERS IN ITALY.

Merkel, J. (2015). Coworking in the city. *ephemera*, *15*(2), 121-139.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Mersand, S. (2021). The state of makerspace research: A review of the literature. *TechTrends*, *65*(2), 174-186.

Mitev, N., De Vaujany, F. X., Laniray, P., Bohas, A., & Fabbri, J. (2019). Co-working spaces, collaborative practices and entrepreneurship. In Collaboration in the digital age (pp. 15-43). Springer, Cham.

Moreira, A., & Zimmermann, R. A. (2012). The importance of collaboration in knowledge management in public services: creating value for stakeholders. In *Customer-Centric Knowledge Management: Concepts and Applications* (pp. 47-63). IGI Global.

Moustakas, C. (1994). *Phenomenological research methods*. Sage publications.

Nascimento, S., & Pólvora, A. (2018). Maker cultures and the prospects for technological action. *Science and Engineering Ethics*, *24*(3), 927-946.

Nicolescu, B. (2005). Towards transdisciplinary education. *TD: The Journal for Transdisciplinary Research in Southern Africa*, *1*(1), 5-15.

Oswald, K., & Zhao, X. (2021). Collaborative Learning in Makerspaces: A Grounded Theory of the Role of Collaborative Learning in Makerspaces. *SAGE Open*, *11*(2), 21582440211020732.

Peppler, K., & Bender, S. (2013). Maker movement spreads innovation one project at a time. *Phi Delta Kappan*, *95*(3), 22-27.

Pettersen, I. B., Kubberød, E., Vangsal, F., & Zeiner, A. (2019). From making gadgets to making talents: exploring a university makerspace. *Education+ Training*.

Poggenpohl, S. H. (2004). Practicing collaboration in design. *Visible Language*, *38*(2), 138.

Rafalow, M. (2016). Tinkering online: Digital supports for making and sharing. In *Makeology* (pp. 158-174). Routledge.

Reich, S. M., & Reich, J. A. (2006). Cultural competence in interdisciplinary collaborations: A method for respecting diversity in research partnerships. *American journal of community psychology*, *38*(1), 51-62.

Repko, A. F., Szostak, R., & Buchberger, M. P. (2020). *Introduction to interdisciplinary studies*. Los Angeles: SAGE.

Resnick, M., & Rosenbaum, E. (2013). Designing for tinkerability. *Design, make, play: Growing the next generation of STEM innovators*, 163-181.

Riley, D. M., McNair, L. D., & Masters, S. (2017). MAKER: An Ethnography of Maker and Hacker Spaces Achieving Diverse Participation. In *2017 ASEE Annual Conference & Exposition*. ASEE.

Ritchie, J., & Lewis, J. (Eds.). (2003). *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. SAGE.

Roldan, W., Hui, J., & Gerber, E. M. (2018). University makerspaces: Opportunities to support equitable participation for women in engineering. *Int. J. Eng. Educ*, *34*(2), 751-768.

Roth, G., & Kleiner, A. (1998). Developing organizational memory through learning histories. *Organizational dynamics*, *27*(2), 43-60.

Saldana, J. (2011). *Fundamentals of qualitative research*. OUP USA.

Salonen, E. (2012). *Designing Collaboration*. MA Communication Design, 14-15.

Scott, G. M., & Garner, R. (2012). *Doing qualitative research: designs, methods, and techniques*. Pearson.

Sheshadri, K. N., Shetty, S., & Babu, A. (2018). Makerspaces in libraries to promote an entrepreneurship: a conceptual study. International Journal on Recent Trends in Business and Tourism (IJRTBT), 2(4), 58-62.

Smith, A. (2017). Social innovation, democracy and makerspaces.

Smith, E. A. (2001). The role of tacit and explicit knowledge in the workplace. *Journal of knowledge Management*.

Spreitzer, G., Bacevice, P., & Garrett, L. (2015). Why People Thrive in Coworking Spaces. Harvard Business Review, 93(7), 28-30

Stock, P., & Burton, R. J. (2011). Defining terms for integrated (multi-inter-trans-disciplinary) sustainability research. *Sustainability*, *3*(8), 1090-1113.

Tan, M., Yang, Y., & Yu, P. (2016). The influence of the maker movement on engineering and technology education. *World Transactions on Engineering and Technology Education*, *14*(1), 89-94.

Taricani, E. (2021). Student Engagement through Collaborative Construction of Knowledge in Makerspaces. In *Design Thinking and Innovation in Learning*. Emerald Publishing Limited.

Taylor, N., Hurley, U., & Connolly, P. (2016, May). Making community: the wider role of makerspaces in public life. In *Proceedings of the 2016 CHI Conference on human factors in Computing systems* (pp. 1415-1425).

Tress, B., Tress, G., & Fry, G. (2005). Researchers' experiences, positive and negative, in integrative landscape projects. *Environmental Management*, *36*(6), 792-807.

Van den Besselaar, P., & Heimeriks, G. (2001, July). Disciplinary, multidisciplinary, interdisciplinary: Concepts and indicators. In *ISSI* (pp. 705-716).

Vettesse, S., & Anastasiadou, C. (2018). IN SITU, 3D PRINTED HERITAGE SOUVENIRS: CHALLENGING CONVENTIONAL SPACES AND CULTURE.

Von Hippel, E. (2006). *Democratizing innovation* (p. 216). the MIT Press.

Vuorikari, R., Ferrari, A., & Punie, Y. (2019). Makerspaces for Education and Training: Exploring future implications for Europe (No. JRC117481). Joint Research Centre (Seville site).

Wardrip, P. S., & Brahms, L. (2015, June). Learning practices of making: developing a framework for design. In *Proceedings of the 14th international conference on interaction design and children* (pp. 375-378).

Weijs-Perrée, M., Van De Koevering, J., Appel-Meulenbroek, R., & Arentze, T. (2019). Analysing user preferences for co-working space characteristics. *Building Research & Information*, *47*(5), 534-548.

Werr, A., Blomberg, J., & Löwstedt, J. (2009). Gaining external knowledge–boundaries in managers' knowledge relations. *Journal of Knowledge Management*.

Wilczynski, V., Zinter, J., & Wilen, L. (2016, June). Teaching engineering design in an academic makerspace: Blending theory and practice to solve client-based problems. In *2016 ASEE Annual Conference & Exposition*.

Zhang, M., Zhao, X., & Qi, Y. (2014). The effects of organizational flatness, coordination, and product modularity on mass customization capability. *International Journal of Production Economics*, *158*, 145-155.

# APPENDICES

## A. CONSENT FORM (IN TURKISH)

**Araştırmaya Gönüllü Katılım Formu**

Bu araştırma, ODTÜ Endüstri Ürünleri Tasarımı Bölümü Yüksek Lisans öğrencisi Özcan Keklik tarafından Doç. Dr. Pınar Kaygan danışmanlığındaki yüksek lisans tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

**Çalışmanın Amacı Nedir?**

Araştırmanın amacı, yaratım atölyelerindeki disiplinler arası ortak çalışma faaliyetlerine organizasyone, mekansal ve sosyal açıdan incelemektir.

**Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?**

Araştırmaya katılmayı kabul ederseniz, sizinle yaklaşık bir saat sürecek olan bire bir mülakat yapılacaktır. Mülakat boyunca size açık uçlu sorular yöneltilecektir. Yapılan görüşmede toplanan verilerin değerlendirilebilmesi için cevaplarınızın ses kaydı alınacaktır.

**Sizden Topladığımız Bilgileri Nasıl Kullanacağız?**

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Çalışmada sizden kimlik veya kurum belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır.

**CONSENT FORM (continued)**

**Katılımınızla ilgili bilmeniz gerekenler:**

Mülakat, genel olarak kişisel rahatsızlık verecek sorular veya uygulamalar içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz mülakatı yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda mülakatı uygulayan kişiye çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz, mülakat sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Endüstri Ürünleri Tasarımı Bölümü öğretim üyelerinden Doç. Dr. Pınar Kaygan (E-posta: pkaygan@metu.edu.tr) ya da yüksek lisans öğrencisi Özcan Keklik (E-posta: ozcan.keklik@metu.edu.tr) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad                Tarih                İmza

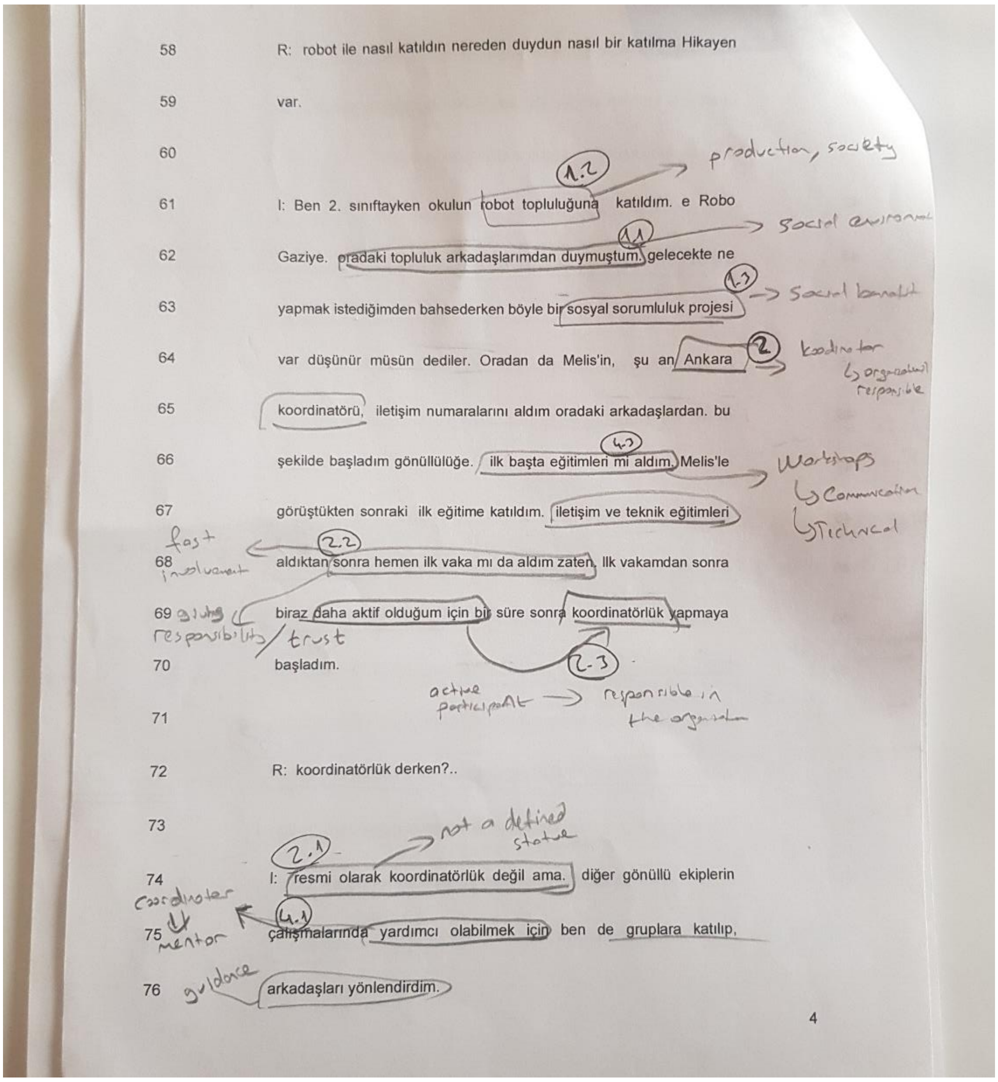
## B. INTERVIEW GUIDE (IN TURKISH)

| 1. **Kişinin genel bilgileri ve yaratım atölyesine katılım süreci** |
| --- |
| ➢ Kendini biraz tanıtabilir misin?<br>➢ Makerspace X'i anlatır mısın? Nasıl kuruldu? Ne yapar kısaca?<br>➢ Nereden duydun, katılma hikayen nedir?<br>➢ Katılma motivasyonun nedir?<br>➢ Kimler kullanabilir burayı?<br>➢ Senin buradaki görevin/rolün ne? |
| 2. **Proje süresince ortak çalışma deneyimi** |
| ➢ Makerspace X'de nasıl projeler yapıyorsunuz? Biraz bahsedebilir misiniz?<br>➢ Bu projelerde genel aşamalar nelerdir? Süreç nasıl ilerler?<br>➢ Bir proje başladıktan sonra iş bölümünü nasıl yapıyorsunuz?<br>➢ Hangi mesleklerden insanlar var?<br>➢ Projeler özelinde kendinizi nasıl geliştiriyorsunuz? Nasıl bir çalışma yapıyorsunuz? Buradaki öğrenme pratiğinden bahseder misiniz?<br>➢ Projelerde birlikte nasıl çalışırsınız? Bu süreçte nasıl koordine olunuyor?<br>➢ Ortak çalışmalarda, toplantılarda, workshoplarda kullandığınız araçlardan ve bu araçları seçmenizin nedenlerinden bahseder misiniz?<br>➢ Ekip içerisinde karar verme süreçleri nasıl oluyor? |

**INTERVIEW GUIDE (continued)**

| **3. Bulunduğunuz mekanın ortak çalışmaya etkisi** |
|---|
| ➢ Çalışma mekanından biraz bahseder misiniz? Mekana girdiğiniz andan itibaren orayı kullanımınızı anlatabilir misiniz?<br>➢ Nasıl buluyorsunuz? Eksiklikleri ya da sevdiğiniz tarafları nelerdir?<br>➢ Mekanın popüler noktaları nelerdir? Bir araya gelinen, sohbet edilen?<br>➢ Mekan ve mekandaki ekipmanların beraber çalışmanıza olan katkıları nelerdir? Mesela proje fikir geliştirmesinde nerede çalışorsunuz? Ne kullanıyorsunuz? |
| **4. Sosyal ilişkiler ve komünite anlayışı** |
| ➢ Buraya dahil olma sürecinden bahsedebilir misin? Yeni gelenler nasıl adapte oluyor?<br>➢ Komünitenin sürdürülebilirliği hakkında ne düşünüyorsunuz? Nasıl bir kültür aktarımı var? Yeni katılan biri üzerinden anlatabilir misiniz?<br>➢ Makerspace X de insanları bir arada tutan nasıl faktörler var? Makerspace üyeleri arasında bir sosyal bağ gözlemliyor musunuz? |
| **5. Önceki iş/staj deneyimleri ile yaratım atölyeleri karşılaştırılması** |
| ➢ Bundan önce farklı disiplinlerle beraber çalıştığın başka proje oldu mu? Buradaki ortak çalışma ortamı nasıldı?<br>➢ Makerspace X de içinde bulunduğunuz ortak çalışma deneyiminiz diğer deneyimlerinize göre nasıl farklılaşıyor?<br>➢ Maker topluluğunda bulunmak, bu kültüre dahil olmak sizin hayatınızda nasıl etkiler oluşturdu? |

## C. CODING THE TRANSCRIPTS



R: robot ile nasıl katıldın nereden duydun nasıl bir katılma Hikayen var.

I: Ben 2. sınıftayken okulun robot topluluğuna katıldım. e Robo Gaziye. oradaki topluluk arkadaşlarımdan duymuştum. gelecekte ne yapmak istediğimden bahsederken böyle bir sosyal sorumluluk projesi var düşünür müsün dediler. Oradan da Melis'in, şu an Ankara koordinatörü, iletişim numaralarını aldım oradaki arkadaşlardan. bu şekilde başladım gönüllülüğe. ilk başta eğitimleri mi aldım, Melis'le görüştükten sonraki ilk eğitime katıldım. iletişim ve teknik eğitimleri aldıktan sonra hemen ilk vaka mı da aldım zaten. Ilk vakamdan sonra biraz daha aktif olduğum için bir süre sonra koordinatörlük yapmaya başladım.

R: koordinatörlük derken?..

I: resmi olarak koordinatörlük değil ama. diğer gönüllü ekiplerin çalışmalarında yardımcı olabilmek için ben de gruplara katılıp, arkadaşları yönlendirdim.

4

Figure C.1 An Example of Coding

## D. TEMPLATE ANALYSIS

### Initial Template

1. Attendance to the community
    1.1. Social environment guidance
    1.2. Productive character
    1.3. Social benefit

2. Organizational structure
    2.1. Flat organization
    2.2. Involvement into the makerspace
    2.3. Organizational sustainability
    2.4. Culture transformation

3. Team dynamics
    3.1. Distribution of tasks independent from disciplines
    3.2. Diversity in disciplines
    3.3. Transdisciplinary concept
    3.4. Necessity of professional knowledge

4. Learning Practices
    4.1. Peer learning
    4.2. Open Sources
    4.3. Workshops

5. Collaborative working through design process
    5.1. Coordination among team members
        5.1.1. Space as a meeting place which enhance coordination
        5.1.2. Online communication tools
    5.2. Production facilities run the design methods
    5.3. Collaborative decision making

6. Makerspace as a collaboration provider
    6.1. Physical space enhance collaboration
    6.2. Physical equipment enable collaboration

7. Maker Community
    7.1. Social ties among makers
    7.2. Community insight

8. Comparison of prior experience versus makerspace experience

9. Effect of maker culture into work life

**TEMPLATE ANALYSIS (continued)**

**Secondary Template**

1. Involving a Collaborative Community : Makerspaces
   1.1. Productive characters
      1.1.1. Multifaceted interest areas
      1.1.2. Passion to have tangible products
   1.2. Encouraging production lab

2. Collaboration characteristics in makerspaces
   2.1. Team dynamics in makerspaces
      2.1.1. Leaning oriented Role Sharing
      2.1.2. Diversity in Disciplines
      2.1.3. Transdisciplinary Concept
   2.2. Collaborative Learning Practices
      2.2.1. Peer Learning
      2.2.2. Workshops
      2.2.3. Open Source
      2.2.4. Learning through tangible products
   2.3. Collaborative Design Process in makerspace
      2.3.1. Space as a collaboration enabler
      2.3.2. Physical Equipment as a Collaboration Enabler
      2.3.3. Prototypes as a collaboration mean
      2.3.4. Tangible end product as an interaction enabler
      2.3.5. Collaborative Decision Making
   2.4. Maker community
      2.4.1. Tools for Community Use
      2.4.2. Collaboration for Local Problems
      2.4.3. Online coordination

3. Comparison of collaboration characteristics between makerspaces and previous experiences
   3.1. Disciplinary borders are blurred
   3.2. Collaborative learning environment is enhanced
   3.3. Multidisciplinarity enabler
   3.4. Encourage

**TEMPLATE ANALYSIS (continued)**

**Final Template**

1. Involving a Collaborative Community: Makerspaces
    1.1. Productive characters
        1.1.1. Multifaceted interest areas
        1.1.2. Productive environment seeking
    1.2. Inviting members by encouraging them to use area
    1.3. Chain of involvement

2. Organizational Dimensions of Collaboration in Makerspaces
    2.1. Team dynamics in makerspaces
        2.1.1. Leaning oriented Role Sharing
        2.1.2. Diversity in Disciplines
        2.1.3. Non-Disciplinary Concept
    2.2. Collaborative Decision Making
    2.3. Collaborative Learning Practices
        2.3.1. Peer Learning
        2.3.2. Workshops
        2.3.3. Open Source
        2.3.4. Learning through tangible products

3. Spatial Dimensions of Collaboration in Makerspaces
    3.1. Space as a collaboration enabler
    3.2. Physical Equipment as a Collaboration Enabler
    3.3. Prototypes as a collaboration mean

4. Social Dimensions of Collaboration in Makerspaces
    4.1. Maker community
        4.1.1. Tools for Community Use
        4.1.2. Collaboration for Local Problems
        4.1.3. Online coordination
    4.2. Matching Makers to Collaborate
    4.3. Social Support to Make

5. Drivers of the Makerspaces
    5.1. Goal-driven Makerspaces
    5.2. Place-driven Makerspaces
    5.3. Comparison of collaboration characteristics between makerspaces and previous experiences
        5.3.1. Blurred disciplinary borders
        5.3.2. Enhanced Collaborative Learning Environment
        5.3.3. Encouraged Productivity