TO SPEAK MAKER:
EFFECTS OF SPEAKING THE DOMINANT SCIENCE LANGUAGE ON NON-EXPERT INDIVIDUALS' SCIENTIFIC AND TECHNOLOGICAL PREDISPOSITION – EXAMINED OVER THE CASE OF MAKERSPACE PARTICIPANTS IN GERMANY

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ABSTRACT

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This study explores how language impacts the understanding and engagement of non-experts in science and technology, with makerspaces serving as a case to examine these experiences. Rooted in the Sapir-Whorf Hypothesis, or linguistic relativity, the research looks at how language shapes the way individuals approach specialised scientific or technological concepts. English, as the dominant language in science, tends to give native speakers an intuitive grasp of technical terms, while non-native speakers often encounter additional challenges that can slow their understanding or even progress. Although a lot has been said about and numerous studies were conducted on how language affects professionals and academia, there is a noticeable gap in the literature when it comes to non-experts. Using ethnographic observation, interviews, and surveys, this research looks into how language influences non-experts' experiences with science and technology, how far these language-based advantages or barriers extend without formal training, and how non-native speakers adapt to these challenges in makerspaces. The findings aim to shed light on how language affects access to scientific knowledge and engagement in individual settings and informal spaces like makerspaces.

Keywords: maker movement, linguistic relativity, dominant science language, language barriers, scientific understanding

ÖZ

ÜRETENCE KONUŞMAK:
BASKIN BİLİM DİLİNİ KONUŞMANIN UZMAN OLMAYAN BİREYLERİN BİLİMSEL VE TEKNOLOJİK ÖNFARKINDALIKLARI ÜZERİNDEKİ ETKİSİ - ALMANYA'DAKİ MAKERSPACE KATILIMCILARI ÖRNEĞİ

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Bu çalışma, dilin uzman olmayan bireylerin bilim ve teknoloji anlayışını ve katılımını nasıl etkilediğini incelemekte, bu deneyimleri araştırmak için makerspaceleri bir vaka olarak kullanmaktadır. Dilsel Görelilik temel alınarak yapılan araştırma, dilin bireylerin bilimsel kavramlara yaklaşımını nasıl şekillendirdiğini gözler önüne sermektedir. Bilimin baskın dili olan İngilizce, anadili İngilizce olan bireylere kavramları kendiliğinden anlamada avantaj sağlarken, anadili İngilizce olmayanlar ek zorluklarla karşılaşmakta ve bu durum anlayışlarını zorlaştırmaktadır. Dilin uzmanlar ve akademik çevreler üzerindeki etkisine dair çok sayıda çalışma mevcutken, uzman olmayan bireylerin deneyimlerine dair bir boşluk bulunmaktadır. Bu araştırma, etnografik gözlem, görüşmeler ve anketler kullanarak, dilin uzman olmayan bireylerin bilim ve teknoloji ile ilgili deneyimlerini nasıl etkilediğini, dil temelli avantajların veya engellerin formal eğitim olmaksızın ne ölçüde var olduğunu ve anadili İngilizce olmayan bireylerin makerspacelerde bu zorluklarla nasıl başa çıktığını incelemektedir. Elde edilen bulgular, dilin bilimsel bilgiye erişim ve bireysel düzeyde bu faaliyetlere katılım üzerindeki etkisini anlamamıza katkıda bulunmayı hedeflemektedir.

Anahtar Kelimeler: maker hareketi, dilsel görelilik, baskın bilim dili, dil bariyerleri, bilimsel kavrayış

To my families

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CHAPTER 1

INTRODUCTION

The relationship between language and cognition has long been a topic of scholarly research, revealing how linguistic structures shape not only communication but also thought and perception. This thesis explores this intersection within the fields of science and technology, focusing on the experiences of individuals navigating these areas without formal expertise. By examining how language serves as both a facilitator and a barrier in informal learning environments, this study highlights the nuanced ways in which linguistic dynamics influence engagement, innovation, and collaboration in contemporary scientific and technological contexts.

1.1. Background

Language plays a fundamental role in shaping human cognition, communication, and, as an inevitable result, our understanding of the world. In scientific and technological contexts, language is not just a tool for communication but also a critical element in how individuals think of or understand complex concepts and engage with these fields of activities. The idea that the structure of a language influences the worldview and cognitive processes of its speakers is not actually new and specific to this study. As it is known today, linguistic relativity was proposed by Benjamin Lee Whorf and surfaced in 1956 with the publication of a portion of his work posthumously. This work inspired this research greatly and presented a basis on which it can be built. Hence, the assertion is that this principle may have significant implications in science and technology, where the dominant science language—currently English—plays a significant role in shaping global engagement with knowledge, in this case, with the knowledge in the areas of science and technology.

A compelling example of linguistic relativity can be seen in the work of Boroditksky (2011), who studied the Kuuk Thaayorre people of Australia. The Kuuk Thaayorre are an indigenous group living in the Pormpuraaw region of Australia. In their language, speakers use cardinal directions (north, south, east, west) instead of relative directions like left or right. This means that they would say, "The pen is to the north of the table," instead of "The pen is to the left of the table." One can imagine how this use of absolute directions requires a constant awareness of one's orientation, cultivating exceptional spatial awareness among the speakers to keep the conversation going, especially when one keeps in mind how the stories they tell need to keep changing based on the location they tell these stories at (Boroditksky, 2011). Boroditsky even demonstrates this awareness by asking a 5-year-old member of Kuuk Thaayorre to point in the north direction, who immediately does so. Boroditsky repeats this experiment at various other venues with reportedly esteemed scientists who need to take their time to make a guess, often with little to no success. This example emphasizes how language shapes cognitive processes, affecting how people perceive and interact with the world. With this said, based on language's effects on our understanding of outer factors, it is safe to assume similar effects of language on our internal or cognitive processes, and our understanding of concepts would also be noteworthy.

In the fields of science and technology, the dominant science language, currently English, has significant effects on engagement with knowledge on a global scale.

David Crystal (2003) notes that English's dominance in academic, scientific, and technological fields arose due to historical and economic factors, such as the British Empire's expansion and the United States' global influence. Even though the reasons for English's dominance around the world are political and have little to do with its relevance to science and technology, this does not change the fact that the majority of scientific papers are now published in English, which can create barriers for non-native English speakers who wish to engage with scientific discourse. This comical picture can be illustrated by how more than 90% of current publications are written in English (Ramírez-Castañeda, 2020) while only 18% of the world actually speaks the language (Eberhard et al., 2024)

These barriers can limit the participation of non-native English speakers in scientific and technological fields, leading to challenges in understanding, collaboration, and innovation. Research by Pennycook (2017) highlights how language supremacy can marginalize non-native speakers, who may feel excluded from global scientific communities due to their limited English proficiency.

This phenomenon is particularly relevant in environments such as makerspaces, where collaboration and knowledge-sharing are essential for participation within the space, and the members are often self-motivated hobbyists. Inclusivity is regularly promoted, and these types of interactions or exchanges are primary ways of skill and knowledge acquisition (Sheridan et al., 2014). Even for the individual maker, on the personal level, Hatch (2014) emphasizes in the Maker Movement Manifesto that collaboration, sharing, supporting, and learning are essential pillars of the maker movement, alongside other key principles. These acts are particularly significant for me and this research because they involve communicative and cognitive processes more prominently than other pillars presented by The Maker Movement Manifesto.

Makerspaces, as collaborative environments, are designed to foster creativity and innovation and bring together individuals from diverse linguistic backgrounds. However, the dominance of English within these spaces can create an uneven playing field, where non-native English speakers face more significant challenges in accessing information, communicating effectively, and participating fully in collaborative projects (Sheridan et al., 2014). As these spaces emphasize hands-on learning and interdisciplinary work based on collaboration, sharing with others and supporting other makers, language barriers can limit the potential of non-native speakers to engage with the scientific and technological concepts being explored fully.

This research examines how language influences non-native speakers' and, more importantly, non-experts' engagement and understanding of scientific and technological concepts, exploring the implications of linguistic relativity and language barriers based on these individuals' experiences around makerspaces and maker activities. By 'non-experts', this study refers to individuals who do not have formal training or education in the specific scientific or technological field under discussion.

1.2. Problem Statement

The rise of English as the dominant science language has created a significant asymmetry in the predisposition toward scientific and technological engagement between native and non-native English speakers. This urgent issue requires immediate attention, as non-native speakers frequently encounter substantial barriers that hinder their access to knowledge and participation in scientific discussions.

Furthermore, while makers provide a compelling case for examining non-expert engagement in these domains, little research has specifically addressed the differences between native and non-native English speakers outside academia or education. The gaps in language proficiency can significantly impact how non-native speakers perceive and engage with scientific concepts, often limiting their ability to contribute meaningfully to collaborative efforts in makerspaces.

This study aims to investigate the asymmetry in scientific and technological predispositions between native and non-native dominant science language speakers, focusing on how these disparities affect their engagement and comprehension in collaborative environments like makerspaces. By exploring this issue, the research will highlight the potential benefits of understanding linguistic relativity and the challenges faced by non-native speakers in accessing and contributing to scientific and technological discourse.

1.3. Research Objectives

The central aim of this study is to investigate how language shapes the scientific and technological engagement of non-native English speakers, particularly those who are non-experts, within makerspaces. Makerspaces, as collaborative environments equipped with tools for hands-on creation and innovation, serve as ideal settings to explore this relationship. This study seeks to achieve the objectives presented in the following table.

Table 1 Research Objectives

Research Objective	Description
Explore the Influence of Language on Non-Experts in Makerspaces	Examine how the dominant science language, particularly English, affects non-expert individuals' understanding and participation in informal science and technology activities within a single makerspace.
Identify Key Language-Related Challenges	Investigate common language barriers encountered by non-native English speakers, focusing on terminology usage and access to technical knowledge in collaborative and individual projects.
Document Strategies for Navigating Language Barriers	Describe the practical methods used by non-native speakers to overcome language-related obstacles, including reliance on visual aids, peer collaboration, and available multilingual resources.
Understand the Role of Language in Makerspace Dynamics	Assess how language shapes non-experts' experiences of inclusivity and collaboration within the selected makerspace, offering insights into linguistic impacts on participation.
Provide Initial Recommendations for Makerspaces	Suggest practical steps for supporting linguistic diversity and accessibility in makerspaces, based on findings from this case study.

1.4. Research Questions

This thesis seeks to address the following key research questions:

- In what ways does being able to use and speak the dominant science language influence scientific and technological understanding or predisposition of non-expert individuals?
- To what extent can this predisposition be used without any further domain-specific formation?
- To what extent does this disposition reflect on the non-experts' experiences within makerspaces?
- How likely is it for a non-native speaker to develop this predisposition through language use?

1.5. Scope of the Study

This study concentrates on the predisposition of non-expert individuals toward scientific and technological concepts, utilizing makers as a representative case. Makers—individuals who engage in hands-on projects that blend creativity, technology, and craftsmanship—provide valuable insights into how non-experts approach learning and problem-solving within these fields (Hatch, 2014; Resnick, 2017).

Makerspaces serve as ideal environments for this investigation, as they facilitate interaction, collaboration, and knowledge exchange among diverse participants (Sheridan et al., 2014). The research will primarily focus on non-expert makers involved in projects within these collaborative spaces, examining their experiences, challenges, language-related strategies and engagement with scientific and technological content.

While the primary emphasis is on makers, the findings from this study are expected to extend beyond this group, contributing to a broader understanding of how non-expert individuals navigate science and technology fields in various contexts (Honey & Kanter, 2013).

1.6. Contributions of the Study

This study makes significant contributions to understanding how language shapes the engagement of non-expert individuals with science and technology, focusing specifically on informal learning environments like makerspaces. By examining the experiences of participants who navigate linguistic barriers in these settings, the research offers valuable insights into the interplay between language, technology, and inclusivity.

First, this study addresses a critical gap in the literature by shifting the focus from academic and professional scientific contexts to non-expert individuals in informal spaces. Makerspaces provide a unique lens to explore how linguistic factors influence engagement, learning, and collaboration outside traditional institutional frameworks. This perspective enriches the existing body of knowledge by bringing attention to an underexplored demographic and setting.

Second, the research provides empirical insights into the specific challenges faced by non-native English speakers in makerspaces. Through a combination of ethnographic observations, interviews, and surveys, the findings reveal how language barriers can limit access to knowledge, hinder participation in collaborative projects, and shape overall experiences within these communities. This detailed documentation offers a nuanced understanding of the lived realities of participants.

Building on these findings, the study delivers practical policy recommendations aimed at mitigating linguistic challenges in makerspaces. Suggestions such as creating multilingual resources, standardizing visual aids, and implementing mentorship programs provide actionable solutions for makerspace managers and community leaders. These policies are designed to improve accessibility and foster a more inclusive environment for all participants.

Additionally, the study contributes to the theoretical discourse on linguistic relativity by exploring its implications in informal and interdisciplinary settings. It demonstrates how language influences cognitive processes and practical engagement with scientific and technological concepts, extending the application of linguistic relativity beyond its traditional domains.

By advocating for the value of linguistic diversity, this research emphasizes the importance of designing makerspaces that are inclusive of diverse linguistic and cultural backgrounds. The findings highlight how multilingualism can be leveraged as a community asset, fostering collaboration and innovation while enhancing the overall inclusivity of these spaces.

Finally, this study lays a foundation for future research on linguistic factors in informal learning environments. The insights gained here can be adapted to other contexts, including educational makerspaces, hobbyist communities, and interdisciplinary collaborations. By shedding light on the relationship between language and participation in science and technology, the study not only contributes to academic understanding but also provides practical pathways for creating more equitable and inclusive spaces for learning and innovation.

1.7. Summary of the Chapter

This chapter introduces the study by exploring the complex relationship between language, cognition, and engagement in science and technology. It highlights how the dominant science language, currently English, affects non-native speakers' ability to access, understand, and contribute to scientific and technological knowledge.

The background section outlines the theoretical foundation of linguistic relativity and its implications for cognitive processes. It emphasizes the challenges non-native speakers face due to language barriers. The problem statement identifies a critical gap in understanding how these barriers impact non-experts, particularly in informal and collaborative environments like makerspaces.

Furthermore, the chapter establishes the research objectives and questions, focusing on examining linguistic influences, adaptive strategies, and inclusivity within makerspaces. Finally, it outlines the scope of the study, emphasizing its relevance to both the maker community and the broader contexts of scientific engagement.

CHAPTER 2

LITERATURE REVIEW

In this literature review, the role of language—particularly English as the dominant science language—in shaping non-expert individuals' engagements in science and technology activities, especially those of non-native speakers of the dominant science language, was explored. Key concepts such as linguistic relativity, the dominant science language, the maker movement, and expertise were examined in detail. The history, current state, and implications of each concept were analysed in their respective sections before a unified conclusion was drawn from the information presented.

2.1. Linguistic Relativity

The concept of linguistic relativity, also known as the Sapir-Whorf Hypothesis, suggests that a language's structure profoundly influences its speakers' cognition, perception, and, as a result, worldview. This intriguing idea means that speakers of different languages may perceive and interpret the world differently based on the language they use, opening up a whole new dimension of understanding human cognition and language.

Whorf (1956), for instance, argued that the language one uses shapes habitual thought. This can be elaborated by his studies on native American languages such as Hopi, which suggest that different linguistic structures lead to fundamental differences in understanding concepts like time and reality itself. Whorf found that the Hopi language's lack of specific tense markers for time led to a different conceptualisation of time compared to languages like English, which have a more linear temporal framework. Edward Sapir (1921), the other half of the name of the hypothesis and Whorf's teacher noted that the linguistic system one grows up with shapes how one categorises and interprets the world. In his work, Language: An Introduction to the Study of Speech, he argued that language is a guide to social reality, influencing not only how individuals perceive the world but also how they interact with it, shaping their cultural and social experiences. Essentially, this means that language serves as a framework or guideline that steers individuals' understanding of reality, impacting their behaviours, social relationships and cultural practices.

More recently than Whorf and Sapir, Lera Boroditsky has provided empirical support for linguistic relativity. Studies by Boroditksky (2011) on an aboriginal community in Australia called the Kuuk Thaayorre people, who have a unique language and culture, showed how language can affect and shape spatial cognition and language users' awareness of other meta-linguistic dimensions. Unlike English speakers, who typically use relative spatial terms for directions like "left" or "right", this community of people use absolute or cardinal directions such as "north" and "west". This linguistic feature results in an extraordinary awareness of geographical orientation, indicating that language can significantly influence or even shape cognitive processes related to this sort of spatial awareness (Boroditksky, 2011). For example, Boroditsky compares the spatial abilities of a little girl from the Kuuk Thaayorre to esteemed scientists coming from English-speaking backgrounds. The little girl, being accustomed to using cardinal directions, displayed an exceptional ability to orient herself geographically when asked, whereas the English-speaking scientist struggled in pointing at one direction when asked during Boroditsky's talks at universities. This comparison illustrates how linguistic structures shape the way people perceive and engage with their surroundings, highlighting the cognitive influences associated with linguistic features. These sorts of findings are indeed significant when considering how non-native English speakers engage with scientific discourse, which happens predominantly in English.

Boroditsky's work has also shown that linguistic differences can affect how people perceive time, gender and causality. For example, in one of her studies, comparing English and Mandarin speakers, Boroditsky (2001) found that Mandarin speakers are more likely to think about time vertically (top to bottom, top indicating earlier), whereas English speakers conceptualised time horizontally. Her findings on this subject suggest that the language individuals speak can influence how they understand abstract concepts. These findings are relevant to understanding how individuals understand scientific or technical ideas that require a specific cognitive framing.

In summary, linguistic relativity underscores the connection between language, thought and engagement or interaction with the world. The insights from Sapir, Whorf and Boroditsky not only emphasise the cognitive influences of linguistic diversity but also illustrate the need to consider it. This consideration promotes a more inclusive environment that could accommodate numerous ways of thinking and understanding the world rather than a singular way of seeing and processing things. It underscores the value of linguistic diversity in our understanding of the world, enlightening us about the richness of different linguistic perspectives and the need to be open-minded in scientific discourse.

2.2. Dominant Science Language

The concept of the dominant science language has evolved significantly over time, and English currently assumes this position. This dominance is not just a historical fact but a current reality that shapes the scientific landscape in which we operate. Understanding this role of English is crucial for anyone engaging in scientific discourse.

The rise of English as the dominant science language can be traced back to all the geopolitical shifts which occurred in the 20th century. David Crystal (2003) attributes English's establishment as the global language of science to the expansion of the British Empire and the influence of the United States of America after the Second World War. During the prior centuries, the 18th and 19th, the British Empire spread English through its colonies, establishing it as a key language for all sorts of activities such as education, governance and, of course, scientific institutions/discourse. However, as mentioned before, English's role as the dominant science language was solidified only after the US emerged as a global scientific and economic powerhouse after the Second World War.

A nuanced account of this transition from a multilingual scientific landscape to the dominance of English is provided by Michael Gordin in his book Scientific Babel: How Science Was Done Before and After Global English (2015). Before the 20th century, German was the leading language for conducting and communicating scientific research, particularly in the fields of physics and chemistry. At this time, French and Latin also held significant roles in scientific discourse. However, the political and economic consequences of the two world wars led to a decline in German influence. At the same time, the English-speaking American research institutions and journals, specifically in English, propelled English itself to its current dominant position.

Ammon and Hamel present statistical evidence that illustrates this shift towards English, starting from the end of the 19th century. Ammon states that by the early 21st century, over 90% of natural science publications and 75% of social sciences and humanities articles were written in English. As illustrated by the graph presented by Hamel (2007) based on data collected by Tsunoda (1983) and data found in Ammon (1998) and Ammon (2006), this shift marginalised other scientific languages, leading to a significant decline in their use. This figure, also presented below, shows the proportional use of languages in scientific publications in the course of a century.

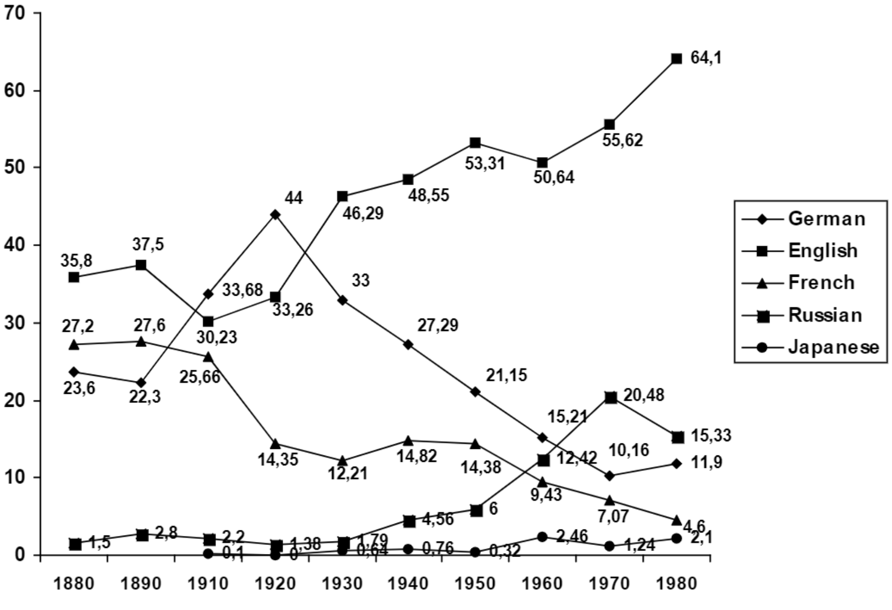

Figure 1 Proportional Language Use in Scientific Publications In The Course Of One Century (Hamel, 2007)

The resulting dominance of English has caused a monolingual scientific community that limits the accessibility and dissemination of research conducted in other languages. This issue is further emphasised by Ramírez-Casteñada. For instance, 92% of the publications by the Colombian researchers she surveyed were published in English, and only 4% were either in Portuguese or Spanish (Ramírez-Castañeda, 2020). In addition, around 81% of these researchers preferred writing directly in English despite the fact that, on average, they need to spend 96 hours writing in English (Ramírez-Castañeda, 2020). These challenges not only hinder the non-native English speaker scientists' ability to contribute to scientific discourse but also worsen the marginalisation of research conducted in languages other than English.

With all this in mind, there is no way of refusing English's position as the dominant science language. The vast majority of scientific journals, conferences, and research institutions use English as their primary language. Montgomery & Crystal (2013) emphasise that English's dominance is reinforced by the publication practices of the leading scientific journals, which predominantly publish in English. This trend has been further exacerbated by digitalisation, where the internet and online databases have centralised English as the medium for scientific communication.

Ammon (2006) highlights that the dominance of English creates structural inequalities within the scientific community. Non-native English speakers must invest additional time and resources to achieve proficiency in English, which can be a significant barrier to fully participating in scientific research. This proficiency requirement acts as a gatekeeper, limiting access to publishing opportunities, funding, and academic mobility for non-native speakers. As illustrated again by Ramirez-Catenada's research.

Ramírez-Castañeda (2020) underlines that non-native English-speaking scientists face substantial challenges in this context, including delays in publication and even biases in peer-review processes due to language-related barriers. According to her findings, around 43% of her responders reported experiencing at least one refusal from journals explicitly because of language issues, and many of them faced additional rounds of revisions to improve language quality. These obstacles inevitably impact non-native English speakers to contribute or benefit from the global exchange of scientific knowledge.

Accordingly, Canagarajah (2012) introduces the concept of translingual practice, which recognises the fluid and dynamic nature of language use among multilingual speakers. In the context of scientific communication, translingual practices can help non-native speakers navigate the challenges posed by the dominance of English. Canagarajah argues that rather than striving for native-like proficiency, non-native speakers can draw on their multilingual repertoires to contribute to scientific discourse in unique ways. He provides the example of a non-native-speaking scientist who uses their knowledge of multiple languages to engage with a broader range of sources, making connections that their monolingual peers might overlook. This example highlights how multilingual perspectives can enrich scientific inquiry and promote more inclusive communication practices. Consequently, this approach challenges the traditional norms of scientific communication and advocates for a broader understanding of language use in science.

The fact remains that the position of English as the dominant science language has several significant implications. Even though the majority of this section of the literature review focused on the negative aspects of this state, English and its position facilitate international collaboration by providing a common language that scientists or individuals from different linguistic backgrounds can use to communicate effectively. This has already, without a doubt, contributed to the rapid dissemination of scientific knowledge and the advancements of research efforts globally. As Gordin also argues in his book, having a common language for science has helped create a more interconnected and collaborative scientific community.

On the other hand, the dominance of English also presents significant challenges for non-native speakers. As Ammon argues, requirements around English for scientific publications create an uneven ground, where non-native speakers are almost always disadvantaged compared to their counterparts, the native speakers. This additional cognitive load also means that these individuals are hindered in terms of their ability to express their thoughts clearly and persuasively, which, in turn, affects their "publishability" and visibility within their respective communities.

Addressing the issues Ramírez-Castañeda mentioned regarding refusals of researchers' works based on language issues, Lippi-Green (2012) discusses standard language ideology. This ideology refers to the belief that there is a single correct form of language that should be used in formal settings, such as scientific communication. This view can also contribute to the before-mentioned marginalisation and refusal of non-native speakers who fail to conform to the norms of what we believe to be standard English.

Similarly, Hamel underscores the dangers of scientific ethnocentrism, which may result from English dominance as the science language. Again, this causes the marginalisation of research produced in other languages, creating a global scientific community lacking diversity and a narrow view of scientific inquiry due to this monolingual state. Instead, Hamel advocates for a plurilingual approach to scientific communication in order to allow a richer and more inclusive scientific community.

Speaking of diversity and the "standard" English, Bolton (2020) explores the concept of global Englishes, highlighting the diversity of English varieties used in scientific communication. While the position of English as the dominant science language is undeniable, the ways in which English is used vary widely across different regions and contexts. Bolton argues that recognising and valuing these different varieties of English can help create a more inclusive scientific community, where no one is pressured to conform to a single standard but is encouraged to use the form of English that suits their needs best. This perspective aligns with three circles of English model by Kachru (1985), which categorises English use into inner, outer and expanding circles, emphasising the diversity of English users while challenging the notion of what the standard form of English is.

The literature also often discussed English as a lingua franca. This term refers to using English as a common language among speakers from different linguistic backgrounds. Seidlhofer (2011) defines English as Lingua Franca simply as a tool for communication among people who do not share a native language. Jenkins (2007) expands on this by highlighting that English as Lingua Franca aims to facilitate communication across diverse linguistic backgrounds rather than enforcing the standards of native English speakers. English as Lingua Franca, therefore, does not require adherence to native norms but instead focuses on intelligibility and mutual understanding, which is particularly relevant for scientific and technical collaborations involving speakers from multiple regions. The use of English as Lingua Franca enables effective international collaboration, making it a crucial tool in science and technology, where communication across borders is essential.

2.3. The Maker Movement

It is safe to say that the maker movement has emerged as a transformative force in the realms of science, technology, and education, with its strong emphasis on creativity, innovation and community-based learning. With the scope of this thesis in mind, it would be beneficial to look into how the maker movement became what it is today.

The maker movement, as we know it, took its modern form in the early 2000s. However, it can be traced to the DIY mindset of the previous century. In its current form, the core principles of making were outlined by Hatch (2014) in his book The Maker Movement Manifesto. Some of the principles that drove this wave of innovation are making, sharing, and giving. Considering that the developments in documenting and sharing one's projects are significant enablers of the maker movement's rise to prominence. The rise of affordable personal computers and widespread internet access played a crucial role, enabling individuals to connect, collaborate and access vast repositories of information and tutorials (Anderson, 2012). In addition, and more obviously (more apparent, the emergence of affordable digital fabrication tools like 3D printers, CNC machines, and laser cutters helped democratise the ability to create, enabling individuals without formal technical training to engage in advanced manufacturing and prototyping (Anderson, 2012).

The publication of Make: Magazine in 2005 by Dale Dougherty is often accepted as the start of the maker movement. Dougherty (2016) underlines the importance of cultivating a culture where anyone can become a maker, leveraging new technologies to bring ideas to life. This movement empowers people by providing the tools and knowledge to innovate and solve problems independently. The significance of these accounts of empowerment, self-directed learning, community collaboration, and accessibility of necessary tools was further highlighted by David Lang (2013) and Adam Kemp (2013).

Another significant milestone in the development and rise of the maker movement was the emergence of the fablabs, pioneered by Neil Gershenfeld at MIT. Gershenfeld (2005) came up with the vision of workshops equipped with digital fabrication tools, such as the ones mentioned before, which would enable individuals and communities to create new technologies and prototypes—additionally, makerspaces as community-focused counterparts to fablabs. Unlike fablabs, which are often more formal and technologically intensive compared to makerspaces, makerspaces are designed to be more inclusive and community-oriented, providing a space where individuals can learn new skills, collaborate, and work on creative projects with or without the need for advanced technical knowledge or expertise (Škec et al., 2020). The global spread of fablabs and makerspaces has created a network of hubs for knowledge-sharing and collaboration.

In its current state, the maker movement is a global phenomenon, with makerspaces and fablabs serving as community hubs worldwide. Anderson (2012) noted that affordable technologies, such as microcontrollers like Arduino and open-source software, have made it easier for individuals to participate in the movement. Online platforms such as Instructables and GitHub facilitate the maker culture by enabling makers to document, share and collaborate on projects with a global audience.

Makerspaces have become important informal learning environments where individuals of all ages can develop scientific, technological and technical literacy (Sheridan et al., 2014). These spaces emphasise learning by doing, where participants acquire skills through hands-on experimentation and peer collaboration. Makerspaces also found their place in formal education; Peppler et al. (2016) discussed how these spaces can provide opportunities for constructivist learning, enabling students to engage in project-based activities that bridge theoretical knowledge with practical application, especially in STEM or STEAM education. For instance, Rabkin and Melo (2019) examined the prevalence of makerspaces in United States state universities. According to their findings, 41% of the institutions had or planned to establish makerspaces, illustrating the widespread adoption of these spaces in educational contexts. Another topic I want to touch upon is inclusivity in makerspaces. For instance, gender inclusivity in makerspaces has been a topic of ongoing research. Melo (2020) explored the inclusivity of these spaces, underlining that gender biases in spatial configurations can impact how individuals navigate and participate. This is why thoughtful design and facilitation are required to ensure that makerspaces are welcoming to all, especially in order to address the underrepresentation of women in STEM or STEAM fields. Melo (2020) also notes that spatial and socio-political factors can also create barriers to the participation of underrepresented groups in makerspaces. For example, she found that male participants were more mobile and engaged with a broader selection of technologies than female participants. These findings show that there is room for improvement to be more inclusive to enable equitable participation from all groups. When the journey mapping technique was used to identify these barriers, it was revealed that individuals' gender identities influenced their engagement, showing that there was a lack of inclusivity in the design of the spaces to accommodate diverse experiences.

With all this said, the maker movement has significant implications for innovation, education, and community development, primarily thanks to the democratisation of technology it is linked with. Providing tools and resources which were previously limited to the use of corporations or research institutions, the movement helped individuals to become creators and actually, makers. As Hatch (2014) argues, this kind of innovation culture empowers individuals to realise their ideas regardless of their backgrounds, types, or levels of expertise. This empowerment also transfers over to underrepresented groups to engage in science and technology (Sheridan et al., 2014). The movement's open nature lowers entry barriers, promoting an environment where diverse persons can learn and participate at their own pace. However, as Dougherty (2016) notes, inclusivity remains a challenge. Even though makerspaces have the potential to be inclusive, barriers such as financial resources, language proficiency, and technical skills remain (Dougherty, 2016). Addressing these barriers is crucial to ensure that the maker movement can be beneficial for all.

From its roots in the Do-It-Yourself culture to its current position as a global movement, the maker movement has enabled individuals and its participants to become creators in many subjects. Today, many makerspaces and fablabs contribute significantly to these people's activities and abilities to learn, innovate, and share knowledge thanks to the democratisation of science and technology. However, actions can still be taken to maximise the maker movement's potential.

2.4. Expertise

Expertise is broadly defined as the level of performance that significantly exceeds that of the average person in a particular domain, often achieved through years of deliberate practice, learning, and engagement with domain-specific knowledge (Ericsson et al., 1993). Understanding expertise involves addressing various facets, such as the definition, processes of attainment, and criteria for detection. Hence, this section of the literature review goes deeper than the term's broad definition.

Ericsson et al. (1993) provide a foundational perspective on expertise, underlining that it is mainly the result of extended deliberate practice rather than innate talent. Based on their framework, expert performance is a consequence of the individuals' extensive efforts to improve their performance while managing motivational and external limitations. This sort of deliberate practice involves activities explicitly designed to improve certain aspects of performance, inversely to plain experience or repetition.

However, external factors, such as quality of practice and feedback, remain significant. Carr (2010) dives into these relationships and suggests that expertise requires interaction, and it is, in essence, historically and culturally situated. Carr argues that expertise is something that people enact rather than something they possess, and this enactment involves complex social interactions and the naturalisation of specific activities as specialised knowledge. This aligns with the sociological view that expertise is not just about the capabilities of individuals but is deeply embedded in social structures and institutional validation.

Similarly, Collins (2018) too describes expertise as being acquired through socialisation within expert communities, underlining the importance of tacit knowledge. Additionally, Collins suggests that expertise does not always need to be linked with exceptional or uncommon domains. Even seemingly ordinary skills, such as language proficiency, can be considered forms of expertise. This perspective broadens the definition of expertise to include skills often overlooked but requiring a high degree of social and practical immersion.

When it comes to detecting expertise, it usually involves evaluating individuals' ability to demonstrate superior performance in domain-specific tasks. For instance, Carr (2010) highlights that expertise is enacted through socialisation practises, namely training and apprenticeship, which help one to develop familiarity with these cultural objects and practices. Therefore, detection is partly contingent on the individual's participation in such processes and ability to demonstrate domain-specific knowledge effectively.

Moreover, there is a cognitive approach to detecting expertise presented by Gobet (2012), which emphasises the role of chunking theory in explaining how experts can process information more effectively than non-experts. The chunking theory is named for the process by which individuals group information into larger and more meaningful units that one could call "chunks", which in return allows for efficient storage and retrieval of information. Experts have the capacity to recognise patterns and structures within their domain that are not apparent to novices, allowing them to retrieve relevant information quickly and solve complex problems more effectively. This cognitive advantage is a key indicator of expertise, and Gobet's work provides empirical support for the importance of mental representations in distinguishing experts from non-experts.

Finally, defining the term "non-expert" in line with this study's findings is essential for the scope of this research. To this extent, a non-expert can be defined as someone who lacks the extensive and structured experience or practice that characterises expertise. Unlike the experts I mentioned throughout this section, non-experts do not possess the deep mental representations that allow for efficient problem-solving and pattern recognition within specific domains (Gobet, 2012). Non-experts may have some familiarity with a domain but lack the procedural fluency and tacit knowledge that come from years of deliberate practice and community engagement (Collins, 2018).

However, this distinction between experts and non-experts may not always be clear-cut. For example, expert amateurs or highly skilled hobbyists may possess significant knowledge and skills in a domain without formal credentials or professional status (Kuznetsov & Paulos, 2010). These individuals occupy a unique space where they may demonstrate high levels of competence but are not recognised as formal experts due to the lack of institutional validation.

2.5. Accessible and Plain Language

Accessible and Plain Language initiatives have emerged as critical frameworks for fostering inclusivity and reducing communication barriers in science, technology, and public engagement. These frameworks aim to bridge gaps between expert and non-expert audiences, particularly in contexts where understanding complex information is essential.

2.5.1. Easy Language

Easy Language focuses on simplifying content for audiences with cognitive and linguistic barriers, ensuring that information is clear and accessible. In Germany, for instance, legal mandates require some public texts to be available in Easy Language, ensuring equitable access for individuals with impairments (Maaß & Rink, 2020). However, translating texts into Easy Language involves more than simplifying vocabulary; it requires anticipating users' prior knowledge and building the necessary contextual understanding to enable comprehension. Effective Easy Language strategies aim to balance information density and cognitive load to avoid overwhelming users, especially in legal or technical contexts, where interaction texts can pose challenges due to their inherent complexity (Maaß & Rink, 2020).

2.5.2. Plain Language

Plain Language, which gained prominence in the 1960s, emphasizes clarity, brevity, and usability, particularly for written communication. As Petelin (2010) notes, the Plain Language movement emerged to address the inequities caused by overly complex and inaccessible language, advocating for user-centred communication practices. Its principles include short sentences, active voice, and the avoidance of jargon, making texts understandable and actionable for diverse audiences.

In scholarly publishing, Plain Language has been effectively applied through Plain Language Summaries. These are short, jargon-free summaries of scholarly articles designed to make complex research accessible to policymakers, healthcare professionals, and the general public (Rosenberg et al., 2023). Formats such as infographics, podcasts, and videos further expand the reach and accessibility of Plain

Language Summaries, enabling tailored engagement for various audiences. Rosenberg et al. (2023) emphasize that Plain Language Summaries are particularly valuable for promoting diversity, equity, inclusion, and accessibility in knowledge dissemination

2.5.3. Implications for Accessibility

Both Easy Language and Plain Language highlight the importance of linguistic inclusivity in democratizing knowledge. By addressing cognitive and linguistic barriers, these frameworks enable equitable participation and comprehension in diverse contexts, from legal systems to academic publishing. Their effectiveness, however, depends on thoughtful implementation, including multilingual support, user feedback, and clear guidelines. Together, Easy Language and Plain Language offer practical tools for fostering inclusivity, ensuring that scientific and technical content is accessible to all.

2.6. Conclusion of the Literature Review

This literature review has explored how language—specifically English as the dominant science language—shapes non-expert individuals' engagement with, understanding of, and predisposition toward scientific and technological activities. By examining linguistic relativity, the dominant science language, the maker movement, expertise, and accessible language frameworks such as Easy Language and Plain Language, the review offers a comprehensive understanding of the barriers and opportunities language presents in science and technology communication.

One of the key findings of this review is the identification of gaps in existing research. While much attention has been given to the role of language in academic and professional settings, there is limited exploration of how non-experts, particularly non-native speakers of dominant science language, navigate scientific and technological contexts. This oversight is particularly critical in informal learning environments like makerspaces, where collaboration and inclusivity are central but often hindered by language barriers. Accessible language frameworks such as Easy Language and Plain Language underscore the importance of simplifying complex information for diverse audiences and have demonstrated potential in bridging communication gaps, particularly for non-native speakers and individuals with cognitive or linguistic challenges.

The dominance of English as the dominant science language has dual implications. While it facilitates international collaboration and the dissemination of knowledge, it also creates significant barriers for non-native speakers, limiting their ability to fully engage with scientific discourse. Accessible communication strategies, such as the use of Easy Language and Plain Language, provide practical approaches to address these challenges, promoting inclusivity and equity in knowledge-sharing.

In conclusion, language plays a pivotal role in shaping access to and participation in scientific and technological activities. The findings emphasize the importance of addressing linguistic barriers, fostering inclusivity, and leveraging accessible communication frameworks to democratize engagement. By integrating insights from diverse disciplines and methodologies, this review lays the foundation for exploring how language can be harnessed to enhance understanding and participation in science and technology, particularly for non-experts in informal and interdisciplinary settings.

2.7. Summary of the Chapter

This chapter explored the multifaceted role of language in shaping non-expert engagement with science and technology, focusing on its cognitive, social, and practical dimensions. The literature review examined key concepts, including linguistic relativity, the dominance of English as the dominant science language, the maker movement, expertise, and accessible communication frameworks like Easy Language and Plain Language. Each section illuminated the ways in which language influences understanding, collaboration, and access to knowledge, particularly in informal learning environments like makerspaces.

The discussion on linguistic relativity highlighted how language shapes thought and perception, influencing how individuals engage with complex concepts. The dominance of English as the dominant science language was found to facilitate global collaboration but also to create barriers for non-native speakers, limiting equitable participation. Accessible language frameworks such as Easy Language and Plain Language emerged as practical tools for addressing these barriers, enabling clearer communication for diverse audiences.

Additionally, the maker movement was presented as a unique case study of informal, interdisciplinary learning, where language plays a critical role in fostering collaboration and innovation. The notion of expertise provided a theoretical lens to distinguish the challenges faced by non-experts, particularly those navigating language barriers in technical contexts.

The chapter identified a critical research gap: the limited focus on how non-native speakers and non-experts engage with science and technology in informal settings. It concluded that addressing linguistic barriers and leveraging accessible communication strategies are essential for promoting inclusivity and democratizing access to knowledge.

This chapter sets the stage for the thesis by providing a comprehensive framework for understanding the linguistic dynamics at play in science and technology engagement. It underscores the importance of fostering linguistic inclusivity and highlights the potential of accessible communication to bridge gaps in understanding, collaboration, and participation.

CHAPTER 3

METHODOLOGY

As previously defined, this study aims to find if and in what ways the ability or use of the dominant science language creates a predisposition and, as a result, an advantage for people who do not actually attain a level of expertise in the subject fields. In this chapter of this study, I am going to go into the methodology, as well as the reasoning behind the decisions made while designing this research.

3.1. Research Design

The research design of this thesis is based on a mixed-methods case study. The idea behind actually using qualitative and “quantitative”, resulting in the mixed-methods design of the research (Creswell, 2015), is to allow a better understanding of both individual experiences and broader patterns in the data for makerspaces in different locations in the world. A case study design was selected to focus on a specific makerspace, Freilab, where diverse linguistic backgrounds exist together. The mixed-methods approach integrates qualitative and quantitative data, providing a fuller analysis of the issue. Qualitative data, collected through observation and semi-structured interviews, offers in-depth insights into how non-native English speakers experience language barriers. This is complemented by quantitative survey data, which captures measurable trends and patterns among a broader population of makerspace participants (Tashakkori & Teddlie, 2010).

A case study design enables the in-depth exploration of language-related challenges in specific makerspaces. It allows the research to investigate how participants navigate linguistic barriers in collaborative, technology-driven environments and provides a detailed understanding of the interactions and projects that emerge in these spaces (Yin, 2018).

Data were collected using a combination of semi-structured interviews and surveys. Interviews provided participants with the freedom to share personal experiences and elaborate on the specific language-related challenges they face, while surveys captured quantitative data on the prevalence and impact of these barriers. This dual approach ensured a more nuanced and balanced data set (Bryman, 2016).

Ethical approval was obtained from the university's ethics committee. All data were anonymised, and participants were fully informed about the study's objectives and handling of their data. For this, they were provided with a Data Confidentiality Statement prior to each interview.

This research design, by integrating qualitative and quantitative data within a case study framework, is expected to provide a robust structure to address the complex issue of language barriers for non-native and non-expert individuals.

In brief, this research aims to answer the following questions:

- In what ways does being able to use and speak the dominant science language influence scientific and technological understanding or predisposition of non-expert individuals?
- To what extent can this predisposition be used without any further domain-specific formation?

- To what extent does this disposition reflect on the non-experts' experiences within makerspaces?
- How likely is it for a non-native speaker to develop this predisposition through language use?

3.2. Research Strategy

This research is primarily qualitative, utilizing ethnographic observation, narrative inquiry, and case study methods. However, I also used surveys to broaden my understanding of the topic. The surveys provided additional remarks, serving as a complementary tool to the qualitative methods rather than as a separate source of data.

Ethnography, narrative inquiry, and case study research were selected as the primary methods due to their ability to capture detailed, contextualized, and personal insights. Ethnography allows for an immersive, first-hand observation of the cultural and social practices within makerspaces, revealing how language shapes interaction and collaboration in real-time. As Patton (2015) notes in Qualitative Research & Evaluation Methods, ethnography is particularly valuable for studying "the lived experiences of participants in natural settings," which aligns perfectly with the goal of understanding these sorts of experiences in makerspace environments.

Narrative inquiry complemented ethnographic observation by focusing on personal stories and experiences related to how language proficiency influences makers' self-activities.

Cases were chosen to provide an in-depth analysis of specific makerspaces. This method allows for a detailed examination of language-related dynamics in context, offering insights into how various factors, such as the space's cultural diversity or the types of projects undertaken, influence language use.

Surveys were integrated to complement the qualitative approaches by reaching a greater number of makers and providing additional layers of data. The surveys were not intended to be separate data sources, but rather they were used to widen the field of view for understanding the influence of the dominant science language on maker activities. I would like to think that the surveys enhanced the representativeness of the research findings by capturing patterns related to the makerspace experience independent of the geographic locations of the spaces.

3.3. Timeline

The timeline for this research offers a clear outline of the key milestones and activities carried out during the study. Below is a flowchart that illustrates the chronological progression of the research.

The research was conducted over a structured timeline to ensure systematic data collection and analysis. Key milestones included the literature review and planning phase, followed by fieldwork comprising ethnographic observation at Freilab, semi-structured interviews with nine participants, and the distribution of surveys. The data gathering was complemented by transcription, coding, and analysis, with the findings synthesized into the final thesis. This timeline reflects a step-by-step approach to addressing the research objectives and maintaining thoroughness and consistency throughout the study.

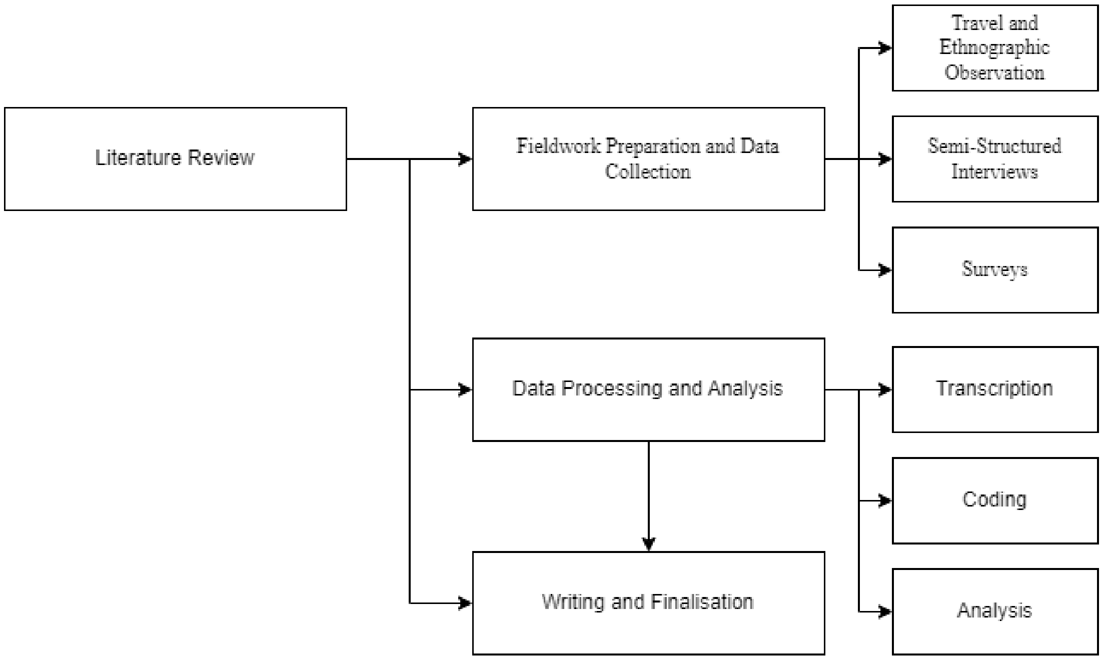

Figure 2 Timeline Flowchart

3.4. Sampling Strategy

Different sampling strategies were employed across the various phases of this research to ensure the selection of participants and settings aligned with the study's objectives. The overall approach can be best described as theoretical sampling, supplemented by purposive sampling for the interviews and convenience sampling for the surveys.

Theoretical sampling, as outlined by Patton (2015), involves selecting cases that will best help to develop and test the theoretical framework of the study. This approach guided the initial decisions, particularly in the choice of makerspace for observation. Based on insights from the literature review and the research objectives, I identified a makerspace that aligned with the study’s focus. This process will be elaborated further in the data-gathering section.

For the interviews, purposive sampling was used, allowing for the selection of participants based on their potential contribution to the study. As described again by Patton (2015), purposive sampling focuses on selecting information-rich cases that provide an in-depth understanding of the subject being studied. In this case, participants were chosen based on their active engagement in makerspace activities and their self-identification as makers, ensuring that their experiences would directly contribute to addressing the research questions of this thesis.

Convenience sampling was also used for the surveys. Due to time and access constraints, surveys were distributed to as many individuals as possible using various channels, such as forums, email lists, Discord, Slack, Facebook groups, LinkedIn contacts and groups, and direct connections in makerspaces.

While convenience sampling introduced some limitations, it was the most appropriate for gathering a broad range of input from makers whom I was able to reach and who were willing to participate.

By combining theoretical, purposive, and convenience sampling, I was able to gather some insights into maker activities and language's influence on them in a flexible or adaptive way.

As promised, in the data gathering section of this chapter, I will explain how I chose the location.

3.5. Context of the Study

Makerspaces are important places for innovation, learning, and collaboration. These community spaces provide tools, equipment, and resources that help people explore their creativity, try new ideas, and create projects. Makerspaces encourage skill development, connect different fields, and promote teamwork in solving problems. The maker movement has made these spaces well-known for making technology accessible to everyone and encouraging hands-on activities.

Freilab, located in Freiburg im Breisgau, Germany, is a private makerspace that focuses on creativity, innovation, and collaboration. It has 116 m^2 of indoor workspace and a functional outdoor area, making it perfect for a variety of creative and technical activities. Freilab supports the maker movement by providing tools, resources, and community help for people from different backgrounds to work on hands-on projects. This study uses Freilab as a case study to examine how language helps non-experts engage with science and technology.

3.5.1. Physical Layout and Facilities

Freilab's layout is carefully organized to support different technical and creative activities.

The space includes specialized zones, each equipped with the tools and resources needed for specific projects. Below are the key areas:

- 3D Printing Area
- General Workspace
- Lounge Area
- Bike Station
- Textile Station
- Electronics Station
- Nerd Corner and Laser Cutter

- Metal Workshop
- Wood Workshop

Figure 3 Freilab Floor Plan (FreiLab, 2021)

3.5.2. Digital Organization and Community

Freilab's community is shaped by both its physical space and its strong digital setup. The Slack workspace is the main tool for communication and organization. As of this writing, there are 616 members on Slack, with different channels focused on specific topics and activities:

- allgemein: General
- einweisungen: Instructions/Onboarding
- neuigkeiten: News/Announcements
- 3d-drucker: 3D Printer

- arbeitssicherheit: Workplace Safety
- aufgaben: Tasks
- grillen_und_spaß: Barbecue and Fun
- marktplatz: Marketplace
- wissenboerse: Knowledge Exchange
- lasercutter: Laser Cutter
- projektbörse: Project Exchange
- projektgalerie: Project Gallery
- wiki: Wiki

These channels, and many more, help members communicate easily and share knowledge, making it simpler for them to find and use the resources in the makerspace.

3.5.3. Cultural and Social Environment

Freilab serves as more than just a technical workspace; it is a community that reflects the values of the maker movement. Its diverse, multinational membership is indicative of Freiburg's status as an international city. This cultural composition creates a platform for observing interactions among individuals from various linguistic and cultural backgrounds. Members include hobbyists, students, and professionals, contributing to a diverse and inclusive environment.

The multicultural and multilingual aspects of the community highlight Freiburg's international character and present an opportunity to examine how language influences collaboration, learning, and participation in technical activities. Freilab promotes a collaborative culture that emphasizes the sharing of knowledge, tools, and resources. Members frequently utilize visual aids, tutorials, and peer support to navigate communication barriers that may arise due to language differences.

The community extends its engagement beyond technical work, hosting events such as workshops, open houses, and social gatherings that help build connections among members. The organized and inclusive atmosphere of Freilab makes it suitable for exploring the intersections of language, technology, and collaboration. The physical layout influences interactions among members and their tools, while the digital infrastructure facilitates coordination and knowledge-sharing. This research aims to provide insights into how language impacts non-expert engagement in makerspaces, offering potential lessons for similar environments globally.

3.6. Data Gathering

3.6.1. Ethnographic Observation

Ethnographic observation played a crucial role in this research. The research topic was partly a result of my self-reflection and autoethnography as a language major with a heavily technical/technological background but lacking expertise in my fields of activity. My ability to comprehend and dissect the words' meanings beyond their phonographic dimension was what made me able to get a better grasp of the scientific or technological concepts I dealt with at the time. This experience, combined with a general idea of the maker movement and what it entails to be a maker, made me wonder about this inevitable linkage between language capabilities and comprehension of domain-specific concepts. This is only a small part and the inspiration behind the research.

The actual observation took place in a makerspace called FreiLab, situated in Freiburg im Breisgau, Germany. Before getting into the actual act of observation, I would like to justify a couple of decisions that led me to take this study to Freilab.

First and foremost, I would like to explain why I chose to conduct this research focusing on individuals who self-identify as makers and participate in maker activities. As the term implies, and previously defined in the definitions section, makers are people who make things. This is quite literally the dictionary definition of the term. However, with the maker movement gaining speed and achieving an unprecedented expansion globally, the term obtained a more specific image, linked with digital tools, electronic projects and so on. The significance of the makers for this study does not lie under these semi-true facts. Their significance comes into the picture with how they learn, document, and share, and most importantly, with how they are self-driven. These individuals are not paid to make, participate in maker activities or join makerspaces. On the contrary, they spare and dedicate their time, energy and other resources in order to make. Consequently, makers who act solely based on and to fulfil their own curiosity are not expected to perform any sort of expertise. They are hobbyists, learners and experimenters. Based on the Maker Faire Maker Market Study Report, when asked, the makers even self-identify as hobbyists or tinkerers, with quite high figures of 48% and 36%, respectively (Make: Community, 2017). In sum, makers present a well-suited case for non-expert individuals showing activity in a certain field. Makerspaces offering communal spaces with suitable equipment for these individuals provide a good site for one to observe and interact with makers.

With this said, another promising aspect of the maker community for this research lies in the maker movement manifesto. In the shorter version of the manifesto, among many of the tenets listed in the manifesto, I would like to underline the ones about sharing, learning, participating and supporting within the maker community. These acts listed in the manifesto go beyond the expected acts linked with making and directly correspond with communicating what has been, is being and will be made. Keeping the global scale and the diversity within the maker movement, it should be easy to acknowledge the part language and communication have to play.

Second, the country of the study. I chose to conduct this study in Germany. There are many sound reasons for this decision, but the main ones are:

- German once was a dominant science language. Hence, it is technical and capable enough to support German speakers' technological and scientific communication. (Rocco, 2020)

- Germany has one of the highest numbers of English speakers. According to English First's English Proficiency Index, Germany is ranked 10th out of 113 countries and is eighth in Europe. (Education First, 2023)

- German is the third most frequently used language online. (Usage Statistics and Market Share of Content Languages for Websites, November 2024, n.d.)

- The life/work balance, satisfaction level and the level of disposable income in Germany are some of the highest in the world. (OECD Better Life Index, n.d.)

- Germany has the second-highest number of fab labs, makerspaces and hackerspaces, only after France, which scores lower in the categories mentioned in the previous article. (Valente et al., 2017)

Thirdly, the selection of Freiburg is mainly linked with Freiburg being a university city with proximity to the French and Swiss borders of Germany. It is as diverse as it gets. According to the university's website and report (University of Freiburg -

University in Numbers | Tableau Public, n.d.) 18% of the school population is comprised of foreigners from all around the world, and not just from European countries close by; the figure below shows the distribution of Freiburg's foreign student population's original countries. This creates diversity and, as a result, an opportunity for this research, which has already been verified during the observation and, more importantly, the interview phases of the research.

The diverse environment and population provided a great opportunity to observe and interact with individuals from various linguistic backgrounds. Additionally, Freiburg is home to a private makerspace called Freilab, which was previously described in the first chapter of this study.

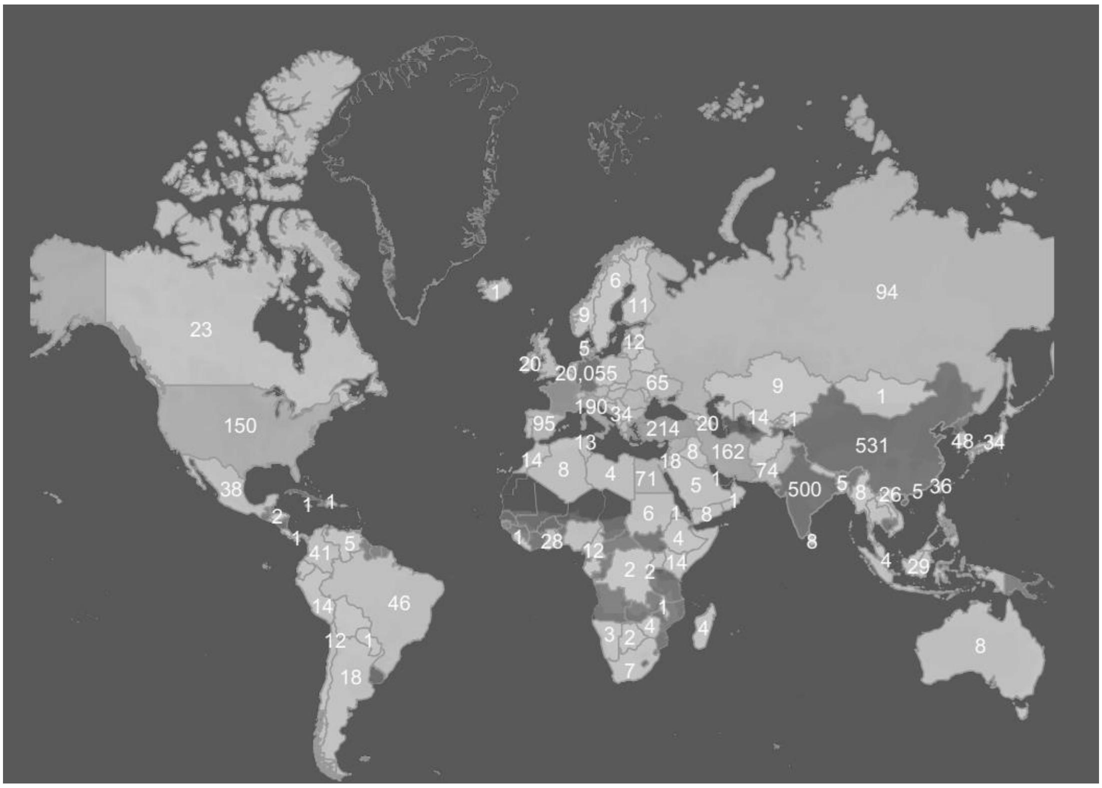

Figure 4 Visualization of student countries of origin at the University of Freiburg (Uni Freiburg, 2023)

3.6.2. Semi-Structured Interviews

Nine semi-structured interviews were conducted with makerspace users. The pseudonyms are assigned arbitrarily and are inspired by the show "Community."

Table 2 Interview Participants

Pseudonym	Age	Country of Origin	Native Language	Other Languages
Abed	30	Germany	German	English, Danish
Jeff	41	France	French	German, English
Troy	44	Germany	German	English
Pierce	31	Germany	German	English
Elroy	29	Germany	German	English
Britta	32	Germany	German	English
Craig	33	England	English	Russian
Ian	27	Türkiye	Turkish	English
Ben	28	France	French	English, Italian

Apart from the interviews themselves, The Language History Questionnaire (LHQ3), a validated tool for assessing multilingual backgrounds and linguistic diversity (Li et al., 2020), was employed to evaluate these interview participants' language use, proficiency, and immersion. However, only eight out of nine of the interviewees were able to respond to the LHQ3. Eight individuals, aged between 27 and 44, participated in the survey, representing native speakers of German, French, Danish, Turkish and English. The LHQ3's structured design captured quantitative data, such as proficiency scores for first (L1), second (L2), and third (L3) languages, and calculated the

Multilingual Language Diversity Score, which quantifies the breadth of multilingual engagement.

The survey collected information on participants' demographics, language backgrounds, and immersion experiences. By using the LHQ3 tool, the research established a systematic and comparable framework for analysing multilingual diversity. This approach contributes to a deeper understanding of language dynamics in collaborative learning environments, such as makerspaces.

Linguistic Backgrounds of the Interview Participants

The LHQ3 data revealed that participants' multilingual profiles were shaped by their native languages (L1) and additional language proficiencies (L2 and L3), as well as their language immersion experiences.

Key observations from the participant data include:

- German Speakers: Five participants (Abed, Troy, Pierce, Elroy, and Britta) identified German as their native language. All reported high proficiency in English as a second language, with one demonstrating proficiency in a third language, such as Danish.

- French Speakers: Jeff and Ben were native French speakers, and both showed high proficiency in English. Jeff also reported proficiency in German, and Ben also reported proficiency in Italian, reflecting their strong multilingual capacity.

- Turkish Speaker: Ian identified Turkish as his native language, complemented by proficiency in English as a second language.

- English Speaker: Craig, a native English speaker, reported proficiency in Russian, showcasing his engagement with a less commonly studied language.

The Multilingual Language Diversity (MLD) Scores calculated from the LHQ3 data highlighted the varying breadth of language engagement among participants. These scores quantified not only language proficiency but also the richness of participants' multilingual experiences, providing a structured framework for analysing their linguistic backgrounds.

For eight of the interviewees who filled the LHQ3, their backgrounds can be presented as follows:

Table 3 LHQ3 Results of Interview Participants

Pseudonym	MLDS	Details
Abed	1.57	Abed is a 30-year-old native German speaker. In addition to his L1, he demonstrates high proficiency in English (L2) and moderate proficiency in Danish (L3). His multilingual profile indicates balanced language immersion and use across multiple contexts.
Pierce	1.00	Pierce, aged 31, speaks German as his native language and has achieved very high proficiency in English (L2). While his linguistic profile focuses primarily on bilingualism, it reflects strong engagement in multilingual environments.
Ben	1.55	Ben is a 28-year-old native French speaker. He has high proficiency in English (L2) and moderate proficiency in Italian (L3), showcasing his ability to engage with multiple linguistic and cultural frameworks.
Ian	1.44	Ian, aged 27, is a native Turkish speaker. He has developed high proficiency in English (L2), reflecting his bilingual engagement and linguistic adaptability.

Table 3 Results of Interview Participants Continued

Craig	0.77	Craig, a 33-year-old native English speaker, has acquired proficiency in Russian (L2), emphasizing his interest in a less commonly studied language and showcasing linguistic versatility.
Jeff	1.94	Jeff is a 41-year-old native French speaker. He has achieved high proficiency in English (L2) and German (L3), demonstrating extensive multilingual immersion and language use.
Britta	1.45	Britta, aged 32, is a native German speaker with high proficiency in English (L2). Her linguistic profile reflects strong bilingual capabilities and significant language use in multilingual contexts.
Troy	1.00	Troy is a 44-year-old native German speaker. He is highly proficient in English (L2) and exhibits a focused bilingual profile that complements his academic and professional background.

Execution of the Semi-Structured Interviews

Google Meet was utilized for the interviews to facilitate direct interaction with participants despite geographical distances. Each session was recorded using OBS Studio to ensure thorough documentation for later analysis.

After conducting the interviews via Google Meet and recording them using OBS Studio, the recordings were transcribed manually to make sure the conversations were accurately captured. The focus during transcription was on the content of the discussions, ensuring that the participants' words and ideas were represented clearly and completely.

This approach gave me a solid understanding of what was said and laid a strong foundation for analysis. The main goal was to capture the essence of the conversations, making sure the key themes around language use and collaboration in makerspaces were reflected properly.

Before the interviews began, I made sure all participants were fully informed about the process. I provided each interviewee with a "Data Confidentiality Statement," which clearly outlined how their personal data would be handled and protected. Additionally, I notified the participants before each recording was started, giving them a chance to ask any questions and ensuring they were comfortable with being recorded.

The interviews followed a semi-structured format. This approach offered flexibility, allowing the discussions to flow naturally while still ensuring that key topics central to my research were covered. The semi-structured approach also gave me the opportunity to explore unexpected but relevant insights that emerged during the interviews. However, a core set of predetermined questions formed the backbone of each session. These questions were prepared to address the research objectives, focusing on participants' experiences in makerspaces, particularly in relation to language use and collaboration.

Each question included in the interviews served a specific purpose. I developed the questions with clear goals in mind, ensuring that they aligned with the broader aims of my thesis. For each question, I considered the rationale behind why it was asked and what insights it would help reveal about the participants' experiences. The goal was to not only collect data but to understand how language influences collaboration, learning, and engagement in a makerspace environment. By providing a mix of open-ended and structured questions, I was able to capture a range of detailed responses that illuminated the participants' perspectives.

The semi-structured interviews aimed to understand participants' experiences with language use, collaboration, and engagement in makerspaces. A detailed list of the interview questions, including their rationale and objectives, is provided in the appendices.

3.6.3. Surveys

To collect data for this study, Google Forms was used to design and distribute the surveys. This platform offered a practical way to reach participants remotely, making it easier to gather responses from a wider range of individuals. The survey was organized into several sections, with each section focusing on different aspects of makers' experiences within makerspaces, particularly in relation to language use.

The survey was divided into 8 sections, each aimed at exploring a specific area. These sections addressed various topics, such as how participants interact within makerspaces, how language impacts their collaborative efforts, their confidence in using the dominant science language, and whether their experiences vary based on their language proficiency.

The survey included a combination of multiple-choice questions, Likert scale ratings, and open-ended questions. This design was intended to collect both quantitative and qualitative data. The open-ended questions, in particular, were added to allow participants to share more detailed experiences, which may provide insights that structured questions by themselves might miss.

The questions in each section were established to align with the research objectives and gather data relevant to the study. However, the effectiveness of the survey in capturing the full scope of participants' experiences remains dependent on the participant's willingness to engage and provide thoughtful responses. The following eight sections attempt to cover a wide range of factors that may influence a maker's experience, from their language preferences to their collaboration and communication strategies in the makerspace.

Survey Sections:

1. Demographic Information
2. Makerspace Usage Habits
3. General Understanding of Science and Technology
4. Accessing Knowledge and Language Preferences
5. Language and Communication in Makerspaces
6. Impact of Language on Learning and Engagement
7. Influence of the Dominant Science Language
8. Open-ended Questions

The survey aimed to investigate participants' demographic backgrounds, their usage habits within makerspaces, language preferences, and how the dominant scientific language affects their learning and engagement. A comprehensive list of the survey questions, along with their rationale and objectives, can be found in the appendices.

As previously mentioned throughout this chapter, surveys were utilized to support, cross-check, and expand upon the findings obtained from the observation and interview phases.

3.7. Data Analysis

Since this study was identified as qualitative research, the data was analysed using an appropriate qualitative framework that combined thematic analysis, narrative analysis, and content analysis. This approach allowed the exploration of how English language proficiency influenced individuals' engagement in scientific and technological activities, using makerspaces as a case study. Inductive coding was used to allow themes to develop organically from the data. The qualitative data analyses were conducted using Requal, primarily chosen for its open-source arrangement.

As mentioned in great detail in the previous section, the data was gathered using the following methods:

- Surveys with open-ended questions (41 responses)
- Semi-structured Interviews (9 interviewees)
- Makerspace Observation (1 week duration)

3.7.1. Analysis Steps

The following steps were taken in order to draw out findings using the data gathered throughout the duration of this study.

Organising the data:

The interviews were transcribed using an online transcription tool called Turboscribe. After the initial transcription, the texts were reviewed, revised, and edited to correct any errors that arose from using automatic transcription. The transcriptions were refined to remove filler words and formatted for better coherence, enhancing readability and facilitating the coding process. The survey questions, including open-ended questions, were compiled into a unified format. This step aimed to facilitate a systematic analysis of all collected data.

Similarly, the field notes from the observation phase were reviewed to identify patterns and create a basis for the narrative of the non-native non-expert makers. Following these steps, the data were imported into their respective software or folders. The data from the interviews and the open-ended questions from the survey were imported into Requal for coding and thematic development. The quantitative data from the surveys were gathered in MS Excel to be prepared for visualisation using graphs and charts for the relevant sections of the thesis.

Coding:

I started coding using open coding, examining the interview transcriptions and applying inductive reasoning to freely and organically create initial codes. Through this approach, I aimed to identify recurring patterns and concepts. Next, I categorized related codes into broader themes to establish their interconnections. Finally, I applied selective coding, focusing on the major themes and key narratives.

Analysis:

For surveys:

The analysis of survey data involved both quantitative and qualitative approaches. Quantitative data was analysed using Excel to identify numerical trends and patterns. For open-ended responses, a content analysis was conducted to measure the frequency of specific terms and concepts. This was complemented by thematic analysis, which explored deeper meanings and shared experiences expressed by participants.

Representative quotes were used to illustrate these themes and patterns and to provide a better understanding of the concepts.

For semi-structured interviews

The analysis of semi-structured interview data focused on identifying themes and patterns related to the role of language. Using thematic analysis, the interview transcripts were coded to identify recurring themes and categories, particularly those related to the use of language and its impact on participation in subject activities. Although the interviews were not transcribed verbatim, key elements of their accounts were highlighted.

For observations

Field notes from ethnographic observations did not undergo thematic analysis directly but served as a supplementary resource to validate and triangulate findings from the survey and interview data. These observations and notes provided context for understanding participant interactions and environmental factors observed in the makerspace. By comparing the field notes with survey and interview findings, I aimed to ensure a more comprehensive and credible interpretation of the results while maintaining consistency across data sources.

Triangulation and Validation:

The results from the analysis of the survey and interviews were cross-checked against each other, as well as the field notes from ethnographic observations. As mentioned earlier, these field notes served as a supplementary resource for triangulation, providing contextual validation and helping to identify overlaps or inconsistencies among the data. This triangulation process enhanced the validity of the findings by ensuring consistency across multiple data sources.

Integration:

Findings from all data sources were combined and organised thematically to provide a cohesive understanding of the research questions. Themes were illustrated using excerpts and representative quotes from participants, ensuring that the results were grounded in the data and provided meaningful insights into the role of language in the scientific and technological engagement of non-experts in makerspace settings. This approach aimed to result in a holistic interpretation of the study's findings.

3.7.2. Tools:

For the processing of the data, the following tools were used during this study.

TurboScribe:

TurboScribe was an advanced transcription platform that used AI to convert audio or video content into text. It combined Automatic Speech Recognition and Natural Language Processing to handle auditory content. TurboScribe was chosen for this study due to its multiple language support, automatic punctuation and formatting features, and, notably, its ability to differentiate speakers. Additionally, it provided a translation option for transcriptions into multiple languages. However, not all of these features worked without error, and some tweaks and corrections were required.

Requal:

Requal was a free and open-source qualitative data analysis software designed to enhance the reproducibility of qualitative research. It ran as a Shiny application within the R environment, offering a basic but sufficient level of functionality for studies such as this thesis, including annotating plain text documents, using user-defined codes, filtering text segments, exporting them, and enabling systematic analysis. It is developed by sociologists at Charles University and the Czech Academy of Sciences.

It was chosen for this study because of its qualitative analysis capabilities, visual tools, ability to triangulate and cross-reference, and, most importantly, because it was open-source software.

Microsoft Excel was used to organize and analyse quantitative data from surveys. Its functionalities were well-known for supporting tasks like generating charts that visually represented numerical findings. This capability complemented Requal by allowing for the integration of both qualitative and quantitative insights.

3.7.3. Ethical Considerations

Ethical considerations were a crucial aspect of conducting this study, ensuring the protection of participants' rights as well as the integrity of the research process. To address these ethical considerations and align with the commitments made to both the ethical research committee and the participants, I anonymized all participant data during the transcription and coding phases to ensure their confidentiality and privacy. Additionally, I documented my coding decisions and the rationale behind them to maintain transparency throughout the coding process. By adhering to these practices, I aimed to comply with established ethical standards.

3.7.4. Data Analysis Conclusion

To sum up, the data analysis part of the methodology chapter was structured to provide a systematic and transparent approach to examining the role of English as the dominant science language in non-expert individuals' engagement in scientific and technological activities, such as those that took place in makerspaces. By using thematic, narrative, and content analysis, this data analysis plan aimed to identify patterns, explore individual experiences, and examine recurring themes of the gathered data. The focus on careful documentation and adherence to ethical practices hopefully ensured the credibility and reliability of the findings. Overall, this approach sought to address the research questions effectively and contributed to the understanding of language use for non-experts within these collaborative and technical environments.

3.8. Conclusion

In conclusion, this chapter outlines the methodological framework used to examine the impact of language on non-expert engagement in makerspaces. By combining ethnographic observation, semi-structured interviews, and a global survey, the research provided a nuanced understanding of linguistic and cultural dynamics. The case study of Freilab, a multicultural makerspace, illustrated the relationship between linguistic diversity and technical participation. Careful sampling and ethical considerations were implemented to ensure participant privacy and autonomy. Overall, this framework lays the groundwork for analysing the findings, highlighting how language affects access, collaboration, and learning in makerspaces.

CHAPTER 4

FINDINGS

This chapter presents the findings of the research, drawing on data collected from interviews, surveys, and ethnographic field notes. The focus is on understanding how early exposure, family and peer influence, hands-on learning, community dynamics, language, and visual communication contribute to the experiences of individuals in makerspaces. The findings explore how these factors collectively shape participants' engagement, skill development and learning processes within makerspaces.

This chapter is structured to address key themes that emerged from the analysis. It begins by exploring the influence of early exposure, family background, and peer support on participants' initial interest in making. The findings underscore the crucial role of family and peers in early involvement in DIY activities, which helps build a foundation for technical skills and fosters a long-lasting interest in making.

Next, the chapter delves into hands-on learning and skill development. Here, the emphasis is on self-directed learning through experimentation, trial and error, and the use of online resources. The findings highlight the adaptability and resourcefulness of makerspace participants, with platforms like YouTube being crucial tools for independent learning, allowing them to acquire technical knowledge outside formal educational settings.

The importance of community and social interaction as factors in learning is then discussed, with a strong emphasis on the role of peer mentorship, collaborative learning, and emotional support. The makerspace community is shown to be instrumental in fostering a supportive environment where participants feel a strong sense of belonging and are motivated to learn, share knowledge, and collaborate on projects.

Finally, the findings also address the influence of the dominant science language on participants' experiences in makerspaces. While proficiency in English facilitates access to technical knowledge and collaboration, it also presents significant challenges for non-native speakers, especially in technical domains like electronics. This underscores the need for inclusivity and support for all participants in makerspaces.

This chapter provides a comprehensive understanding of the factors influencing learning and engagement in makerspace through these findings. It highlights both opportunities and challenges participants face as they navigate technical skills, community dynamics and language barriers.

4.1. The Codes and Clusters

The analysis of qualitative data in this study involved a structured coding process, enabling the identification of recurring themes and patterns. These codes were further grouped into clusters to capture the nuanced ways in which language influences participation and interaction within makerspaces. The resulting codes and clusters provide a comprehensive framework for understanding the linguistic and cultural dynamics that shape non-experts' experiences in these environments. A detailed breakdown of the codes, their definitions, and corresponding clusters can be found in the appendices.

4.2. Early Exposure, Family and Peer Influence on Engagement in Making

Early exposure to making activities, family involvement and peer support were significant factors in shaping participants' interest in technical skills and making. Data from the interviews and ethnographic field notes illustrate how early experiences and social influences fostered a predisposition towards practical experimentation and skill development.

Family influence plays a significant role in shaping individuals' initial interest and engagement in making activities. Early exposure to technical skills and DIY projects, often facilitated by the parents or other family members, helps develop foundational skills and fosters a natural curiosity for making and experimenting. Family members who are skilled in hands-on work create environments where activities such as exploration, tinkering and problem-solving are encouraged.

In the interviews, several participants emphasised the significance of family influence in their early engagement with making. Craig explained:

> *I had my own shed, just a small garden shed. And I would often just, I'd be with my parents or something driving around. And then I'd take an interest in an old television or a vacuum cleaner or something by the side of the road. I'd be like, 'Oh, I want to take that home.' And then I'd just take it apart. I've been electrocuted a few times. You know, I've kind of learned the things that I can do and I can't do just by trial and error.*

Craig's experience of exploring discarded household items in his garden shed as a child and learning through trial and error shows how his early environment fostered an atmosphere of curiosity, leading him to develop a hands-on understanding of how things worked and a sense of DIY enthusiasm.

Similarly, Ian shared how his family's encouragement, simply by providing him with a piece of cloth on which he could realise his proto-maker activities, enabled him to channel his creativity into making projects from a very young age. He stated:

> *As a child, I was always using scissors and glue. I had a cloth that I would lay on the ground whenever I was going to make something so as not to mess up the carpet. On that cloth, I would cut things with scissors. I was always inclined to cut and paste things with paper and glue. I even used the cartons of four-packs of five-litre water bottles to make castles, adding structures with my Legos inside. I built houses and was constantly busy making models; my interest in making things began even before elementary school.*

Ian's anecdote emphasizes how this simple act of providing him with materials and space allowed him to cultivate his creativity, turning everyday objects into opportunities for experimenting.

For Jeff, making was closely intertwined with his family's livelihood, considering that his parents built their own house on two occasions. Jeff's father's work as a handyman and carpenter laid the foundation for Jeff's skills. He describes his experiences:

> *I came to the plumber technique because my father is a handyman. He had his company of carpentry and wood houses. And, you know, my parents built their home. Yeah, three homes. And that was constantly like a construction site. Since I'm a kid, yeah. That's cool. I learned all my life how to build things. But as a kid, I wasn't really interested in that, you know. I learned by, yeah. I built a boat by myself as I was 14 years old. A full-size boat for a person. Yeah, but that was 2.50 meters long. And with only one sail and two rows. I mean, I don't recall a lot of... I mean, I don't know. I was guided by my father.*

His account provides a vivid example of how making was part of daily life for him, from building homes with his parents to crafting his own boat at the age of 14. The combination of learning through hands-on work and being guided by his father contributed to his deep technical knowledge and skills.

Abed also spoke about how growing up in a family of makers shaped his skills and interests. "My dad's a carpenter. I grew up in carpentry in Denmark, so I do like working with wood, and I enjoy the high-tech parts of it as well as the hands-on, get-your-hands-dirty kind of work," he explained.

Abed’s background highlights the influence of his father, who helped him blend traditional craftsmanship with a fascination for technology. This fostered a well-rounded skill set that combined both physical and digital skills.

On the other hand, Elroy was influenced by his brother, whose involvement in makerspaces inspired him to follow a similar path. He explained:

> *I was building my van. I knew from my brother, he was in Karlsruhe, that there was a place where you could have a Makerspace or there was a Makerspace or like a shared woodworking place. He was already into that kind of stuff, and it made me want to explore it too. Eventually, I found Freilab in Freiburg, and that’s where I really started getting into woodworking and learning new skills.*

Elroy’s experience shows how siblings can play a crucial role in introducing individuals to new opportunities, such as makerspaces, which further deepened his engagement in hands-on projects and expanded his skill set.

In addition to familial influence, the interviews and the observations highlighted the importance of peer support and community in encouraging making. Peer influence was prominent in the makerspace as well, with participants frequently supporting one another, arranging station-specific introductions, and sharing knowledge through

Slack. These interactions created a collaborative learning environment where community support played a key role in skill development and engagement.

Britta's experience further illustrates the significance of peer influence. In her interview, Britta described how her journey into making began with the encouragement from a friend:

> *A friend of mine... infected me with the interest in making. He joined the Makerspace first and then asked me if I would like to join, and I did. At first, I was hesitant because I wasn't sure if I would fit in, but the community was very welcoming. It didn't take long before I was hooked, and I started learning about all the tools I could use there.*

Britta's example demonstrates how peer encouragement can play a pivotal role in motivating individuals to join makerspaces and immerse themselves in new learning experiences. The welcoming atmosphere also ensured that she felt supported, enabling her to explore making without fear of judgment.

Of course, the influence of peers was not limited to initial engagement but extended to skill development within the makerspace. Observations showed that participants were encouraged by friends and mentors to try new tools and techniques, which helped them gain confidence and expand their skill sets. Peer encouragement was instrumental in enabling participants to step outside their comfort zones and engage in diverse making activities, ultimately fostering a more inclusive and dynamic makerspace community.

The convergence of interview narratives, field observations and examples like these participants highlight that early exposure, family involvement and peer support are foundational elements in fostering a lasting interest in making. These factors provided both initial motivation and ongoing support needed to cultivate practical skills and actively engage in makerspaces.

4.3. Hands-On Learning and Skill Development

Hands-on learning and practical experimentation are at the core of skill development for many makers. Participants emphasised the value of self-directed learning, which involved an iterative process of trial and error. The ability to experiment, make mistakes, reflect and retry was a central aspect of building technical competence, particularly when formal educational pathways were not available or sufficient, or as in some of these cases, not chosen. This self-teaching process allowed participants to develop skills independently at their own pace and often using accessible online or digital resources.

Self-teaching was a hallmark of the participants' approach to learning in the makerspace. Unlike traditional learning environments where structured curricula dictate the pace of and content of knowledge acquisition, makers engaged in more open-ended, exploratory processes. The self-directed learning approach was characterised by a personal motivation to understand and create, often driven by the individuals themselves. Makers were able to set their own goals and take ownership of their learning journey, which fostered a deeper connection to the new skills they acquired. Participants spoke of the freedom to take on projects that interested them, allowing their learning to be guided by their own needs and requirements of the specific projects they wanted to complete.

Independent research or exploration played a crucial role in reinforcing self-teaching. Makers often described the importance of diving into projects headfirst, even when they lacked prior knowledge about specific tools or techniques. This meant that much of their learning was experiential, meaning they tested out different methods, made adjustments, and improved as they went along. Independent exploration was not just about applying the things they had learned. It was also about discovery. Many of the participants talked about how, through exploration, they developed not only technical proficiency but also the resilience and creativity needed to overcome obstacles. Ian explains:

> *Initially, I would create things without reference, purely through observation of how things worked and moved. As I progressed, I started thinking more deeply about how things fit together. In elementary school, I even had ideas about perpetual motion—trying to invent something that could work endlessly. I remember trying to animate with Flash Player before it became an Adobe product, creating animations frame by frame.*

A certain facilitator of both self-teaching and independent exploration was leveraging online resources, especially YouTube. The availability of digital resources transformed the learning landscape for makers, providing them with the means to acquire highly specialised skills without the need for formal classes or professional training. YouTube, in particular, emerged as a pivotal tool for participants. It offered wealth of tutorials that covered a wide array of subjects, ranging from basic woodworking techniques to advanced CAD modelling and software use.

Participants found YouTube to be an invaluable resource because it allowed them to learn visually and revisit complex topics at their own pace. The platform's accessibility enabled them to immediately translate the theoretical knowledge gained from videos into practical, hands-on applications. Pierce explicitly highlighted his reliance on YouTube for learning design software:

> *I work a lot with Inkscape for vector drawing… I learned Inkscape by myself only by internet resources. Usually, it's YouTube. It's one channel. I think it's called Logos by Nick. He was the first that I found*

> *who did a lot of work with Inkscape, and they were quite, for me, quite comprehensive.*

This demonstrates how Pierce used YouTube to gain foundational knowledge that he could then apply practically in his projects, from laser cutting to CNC milling. The platform's role was not limited to introductory lessons. It also served as a continuous support system, offering tutorials that could be revisited whenever Pierce needed to refresh or enhance his skills.

Abed also stressed the importance of online tutorials when learning more specialised tools or subjects:

> *Finding software resources in German can be quite challenging. For instance, when you delve into the details of Revit, a complex program, you'll notice that comprehensive German tutorials are lacking. While you can find general information in German, in-depth explanations are primarily available in English. My first exposure to English came when I was young, as I watched videos and learned by figuring out what to do in various scenarios.*

For Abed, learning tools like CAD software, which has steep learning curves, was made possible through YouTube. Also, since instructional material in his native language was limited, YouTube became an essential resource for accessing detailed, step-by-step guidance in English. These tutorials allowed him to progress from basic to more advanced skills, adapting traditional carpentry knowledge to digital design contexts.

Participants also spoke about other online resources, such as Thingiverse, which offered downloadable 3d models that could be printed and used. For instance, Pierce noted that his venture into 3D modelling and printing commenced using these pre-made models.

Platforms like Thingiverse provided a starting point for participants who were new to 3D printing. By downloading and modifying existing models, makers could focus on understanding the functionality of the printer itself rather than having to design intricate models from scratch to utilise these tools, lowering the entry barrier and allowing for quicker engagement with the technology, reinforcing self-directed learning.

Another critical aspect of leveraging online resources was the flexibility it provided. Participants could access a wide array of tutorials at any time, allowing them to tailor their learning experiences to fit their schedules and the demands of their projects. This was especially important for those who preferred to learn through visual demonstration rather than written manuals. Online tutorials filled the gap between theoretical learning and practical application, giving makers the confidence they needed before attempting new skills independently.

While online resources were essential for initiating learning, community engagement in makerspaces provided participants with opportunities to refine and enhance their skills through peer support. Makerspaces offered an environment where individuals could receive guidance from more experienced members, allowing them to move from basic proficiency to advanced skills. Community learning complemented independent exploration by providing the reassurance and expertise that participants needed when they encountered challenges.

Ben highlighted how inspiring it was to be part of a community where ideas were exchanged openly, "We exchange ideas together, and we also see the different projects of other people. And this is really inspiring." This kind of collaboration and exposure to others’ projects created a dynamic environment where learning was continuous and collective. Participants could take ideas from others, adapt them to their own projects, and in doing so, deepen their understanding of both tools and techniques.

Britta also witnessed the support of her makerspace community, "They were really welcoming… they all know each other, and they help out each other when they need a hand.” This sense of belonging and collective growth allowed her to comfortably attempt new skills, knowing that she had a supportive network to turn to whenever needed. It also reinforced the idea that learning in makerspaces is not just an individual journey. It is also about contributing and benefiting from a shared pool of knowledge.

Troy underscored the complementary nature of online tutorials and community support:

> *One specific tool that I really want to learn about is the oscilloscope. It's something where I think I'll not do just watching tutorials, but I will ask somebody at Freilab to show me, just because then I can make sure that I'm actually doing it with the oscilloscope that's there at Freilab*

While online resources like YouTube, and even AI models like ChatGPT provided Troy with a foundational understanding, the hands-on assistance from someone experienced ensured that he could correctly apply that knowledge in practice. This blend of self-teaching through online resources and community mentorship was a recurring theme across the data, illustrating how independent and collaborative approaches to learning complemented one another.

In addition to one-on-one guidance, many participants also benefited from volunteer-driven inductions and trainings that were offered as regularly as possible within the makerspace. These inductions often focused on teaching members how to use specific tools and workstations, ensuring that everyone had a baseline understanding of how to operate safely and effectively. The volunteer nature of these sessions emphasised the collaborative ethos of the makerspace community, where more experienced members were willing to contribute their time and knowledge to help newcomers.

This combined approach leveraging digital learning resources like YouTube for foundational knowledge and relying on community-based volunteer-driven support for practical skills allowed participants to build both theoretical and applied skill sets. The ongoing availability of volunteer-driven trainings and inductions ensured that makerspaces were accessible to everyone, regardless of prior experience, thus fostering an inclusive environment where learning is supported both digitally and communally.

In summary, skill development in makerspaces is characterised by a blended approach, one that integrates self-teaching, independent exploration and the use of online resources such as YouTube. Participants relied on YouTube to gain a visual, accessible introduction to complex tools and techniques, which they then applied independently. Mistakes were embraced as valuable parts of the learning journey, providing critical insights and deepening technical understanding. This approach was further enriched by the collaborative and supportive community found within makerspaces. Peer support allowed participants to refine their skills, receive feedback and gain confidence. Together, these elements create a dynamic learning environment where makers can grow and innovate, driven by curiosity and supported by both digital and human resources.

4.4. Community and Social Interaction as Factors in Learning

As mentioned in the previous section, community engagement was a significant factor in shaping the learning experiences of participants within the makerspace. The collaborative nature of the community fostered an environment where knowledge sharing was commonplace, and learning was enriched through both individual experimentation and peer support. The presence of a diverse group of individuals, each bringing unique skills and perspectives, allowed participants to engage in a variety of activities, from woodworking to electronics, often in ways that traditional educational settings do not accommodate.

Participants described the value of learning through collaboration. The makerspace's open structure encouraged individuals to approach one another, observe different projects, and actively participate in shared problem-solving. For many, this type of collaborative engagement was a powerful motivator, helping them to overcome challenges that might have been daunting if faced alone. The community atmosphere made it easy for participants to find answers to their questions or receive advice, which facilitated continuous learning and encouraged members to take creative risks. The role of peer mentorship was another key aspect of community engagement. Experienced makers took on informal mentorship roles, offering guidance to those who were new to making or less familiar with specific tools or technologies. This mentorship was often volunteer-driven, reinforcing the community spirit of the makerspace. Jeff described his experience of guiding others in Freilab, "I have seen that some makers were struggling. I could help and guide them in the right direction four or five times, maybe. I mean, that was as I was the only one to help."

Jeff emphasised mentoring others, not only the newcomers but also his own growth as a maker. Similarly, Ben spoke about his role in giving introductions at the Freilab, highlighting his active contribution to the community by providing structured learning opportunities for new members:

> *"I'm also interested in sharing this knowledge by giving some introductions, so some introductions. I'm taking care of giving the CNC introductions at Freilab. Yeah, that's correct. I think I give more than I learn now at the moment"*

Ben's commitment to giving back to the community through mentorship illustrates how experienced members help newcomers navigate the complexities of using specialised tools, fostering a culture of reciprocal learning.

Pierce also highlighted the importance of mentoring within the makerspace, noting how he often provided introductions and supervised tool usage to help ensure the newcomers work effectively and safely:

> *I took on the position of, uh, I would call it workshop supervisor. So, people are, my last makerspace was a bit more accessible for doing these tool introductions. So, it was a lot faster and it was usually one-on-one. So, you could just have like a small talk about it, tell them, okay, this tool works like this. You do these steps. And you watch out for these things.*

Pierce's experience of serving as a workshop supervisor underscores the informal but critical nature of mentorship in the makerspace. His willingness to provide one-on-one support through personalized introductions ensured that newcomers could learn at their own pace and gain hands-on familiarity with the tools. This type of mentoring not only helped to build skills for the "mentees" but also strengthened the overall safety and functionality of the workshop by reducing the risk of improper tool use.

Abed also described the value of seeking guidance from others in the makerspace:

> *I think it's so cool to just like pop in and ask them something. So, like, everywhere where I don't have enough expertise or where I think like, you know what, he looks like he knows stuff, I would totally pop in and ask definitely.*

Abed's experience of being able to approach more knowledgeable members for help demonstrates the value of having access to a supportive network within the makerspace. The open environment allowed participants to seek assistance without hesitation, making learning more approachable and fostering confidence.

The value of the community was also evident in the way knowledge was shared across different areas of making. The diversity of skills present in the makerspace enriched the learning process, as members could learn about disciplines that were outside of their usual expertise. This cross-pollination of skills was not only instrumental in broadening participants' capabilities but also in fostering a mindset of continuous, interdisciplinary learning.

Beyond the practical aspects of learning, emotional support and well-being were significant benefits of being part of the makerspace community. Participants often described the makerspace as a place where they could express their creativity freely and without fear of judgment. The sense of belonging that came from being part of a collaborative, welcoming environment was vital for many individuals. Ben spoke about the importance of being part of a community:

> *There are three things I like about Freilab and being there. I need and I want to be part of a community. I need and want to be able to use tools in order to go forward on my projects. And the last thing I need, I want to share knowledge. This is why I'm happy to meet people and to get to know what they're into.*

For Ben, the sense of belonging was intertwined with the opportunity to use tools, work on projects, and share knowledge, all elements that made his makerspace experience fulfilling and motivating.

The social interactions that occurred within the makerspace also played a crucial role in providing emotional support. Many participants mentioned that engaging with like-minded individuals created an important social outlet.

Additionally, Elroy touched on the emotional benefits of working in the makerspace:

> *Sometimes for me, when I go to the Freilab, it's also something I like to do for my own, just for, you know, like being in a woodworking shop and just doing some meditation. And just having the time for my own. It's something I really enjoy doing. That's maybe also why I, for now, did most projects on my own, because I also like that too.*

This experience underscores how making was not only a practical endeavour but also a source of mental well-being. The makerspace allowed him to engage in activities that provided both a sense of solitude and a creative outlet, highlighting the flexibility and emotional value of the space.

Finally, the process of making itself, combined with the supportive atmosphere of the community, had positive effects on participants' mental health. Being involved in creative and problem-solving activities allowed participants to channel their focus into constructive pursuits, which often brought a sense of fulfilment and relief from stress. The encouragement and positive reinforcement from peers further elevated these benefits, creating an environment where participants felt motivated, supported and inspired.

In conclusion, the community and social interactions within the makerspace were not only integral to the learning process but also crucial for fostering motivation, well-being, and emotional support among participants. The blend of collaborative learning, peer mentorship, and emotional support created an enriching environment where members could grow both technically and personally. Hence, the makerspace served as a hub of creativity, learning, and support, where the value of community was evident in both practical skill development and enhancement of members' overall quality of life.

4.5. Influence of the Dominant Science Language

The Dominant Science Language, namely English, plays a significant role in shaping the participants' experiences in maker spaces. Proficiency in English is crucial for accessing a wide range of technical knowledge and online resources, especially for learning about complex technical fields. However, the influence of the dominant science language varies depending on the type of activity, with higher dependency noted in technical domains such as electronics and software programming compared to practical, hands-on tasks like woodworking.

Proficiency in English is often seen as a gateway to knowledge. Participants who were proficient in English had easier access to high-quality technical resources, including research papers, digital manuals, and online tutorials. English serves as the dominant language for many online platforms like YouTube, where participants can find detailed guides and instructional videos on how to operate specialised tools or undertake advanced projects. This proficiency allows learners to directly benefit from a broader pool of information without relying on translation, making their learning journey more efficient. Craig highlighted the ubiquity of English in accessing information, "Pretty much everything is available in English. If I'm buying a product, like, you know, cells, for example, like, they're going to have data sheets in English anyway."

He emphasizes the dominance of English as the primary language for technical resources, reinforcing the role of English as a critical factor in accessing and understanding technical information.

However, the dependency on English as the dominant science language is not uniform across different activities within the makerspace. For technical fields such as electronics, programming and 3D printing, participants were more reliant on English due to the availability of resources primarily in that language. Accessing advanced concepts, troubleshooting problems or understanding detailed technical instructions often required fluency in English, as many specialised terms and instructional guides did not have suitable equivalents in other languages.

Abed explained the challenge of finding tutorials in German and the reliance on English for in-depth technical content, "When it comes to software, it's quite hard to find something in German, especially when it's very detailed into, like, CAD or something. You get the main thing in German, but the depth of it, you would only get in English."

This indicates that while introductory content might be available in participants' native language, deeper, more specialised learning often required proficiency in English. Ben also emphasised that English serves as the primary technical language for maker-related topics, "I think, I would say that English is for me the most practical language to use to deal with technical subjects, linked with makerspace and maker things, like software development... There is always an English database of information about the thing."

This quote highlights how English is viewed as a practical necessity for accessing technical information related to making, from software development to more specialised tools and projects.

Survey findings also indicated a clear age-based trend regarding the preference for English as the dominant science language for science and technology content. Younger participants, particularly in the 18-24 and 25-34 age groups, were more likely to use English or a combination of English and their native language.

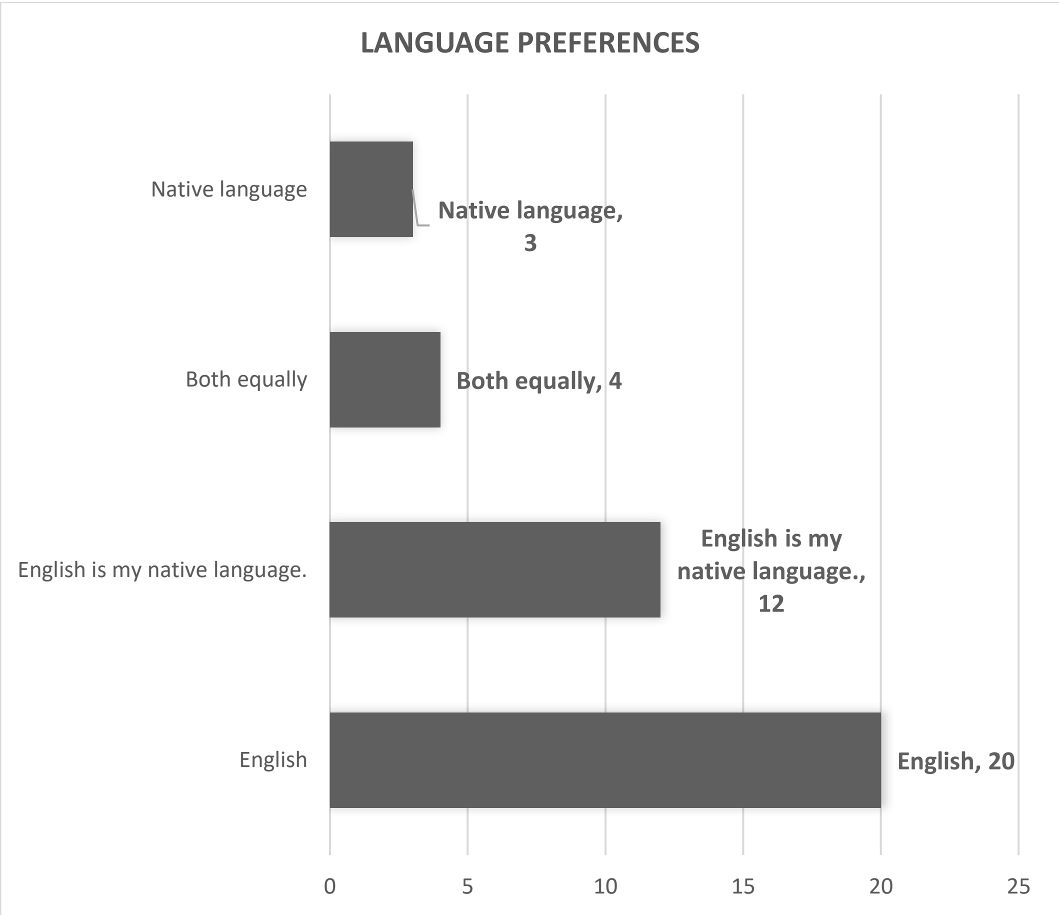

Figure 5 Language Preferences of Respondents

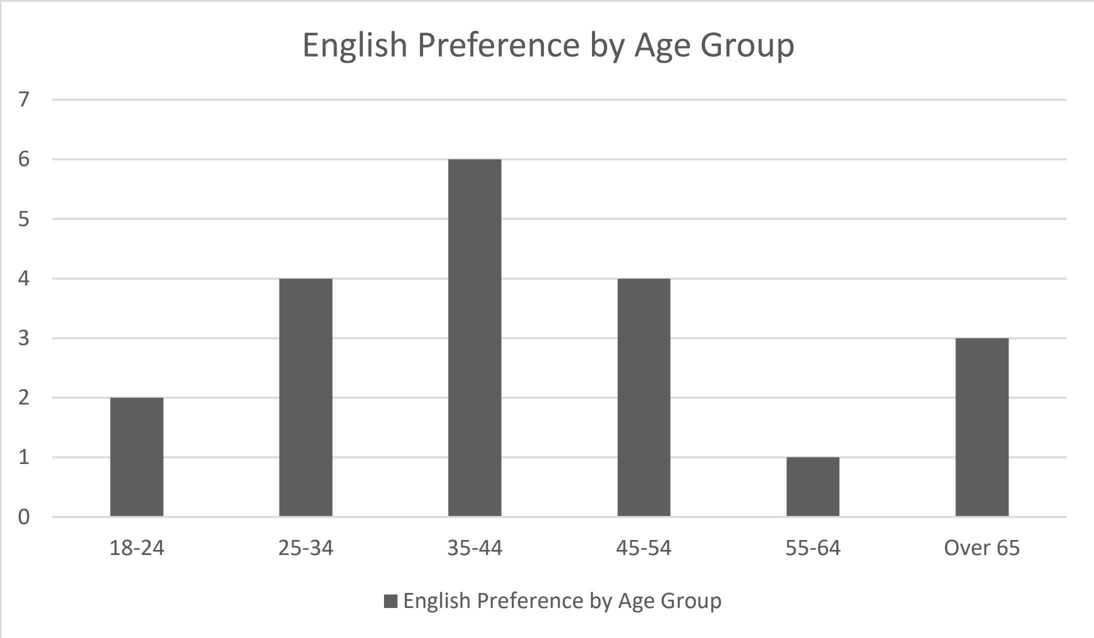

Figure 6 English Preference by Age Group

This trend suggests that younger individuals are more comfortable navigating scientific and technological content using English, likely reflecting generational differences in exposure and proficiency with the language. Furthermore, younger participants who preferred English also reported higher engagement levels with scientific content, showing English proficiency is linked to improved access to scientific and technological resources and increased interaction with technical subjects.

Survey data also showed that participants in the 25-34 and 35-44 age groups who preferred using English reported higher confidence in makerspace activities.

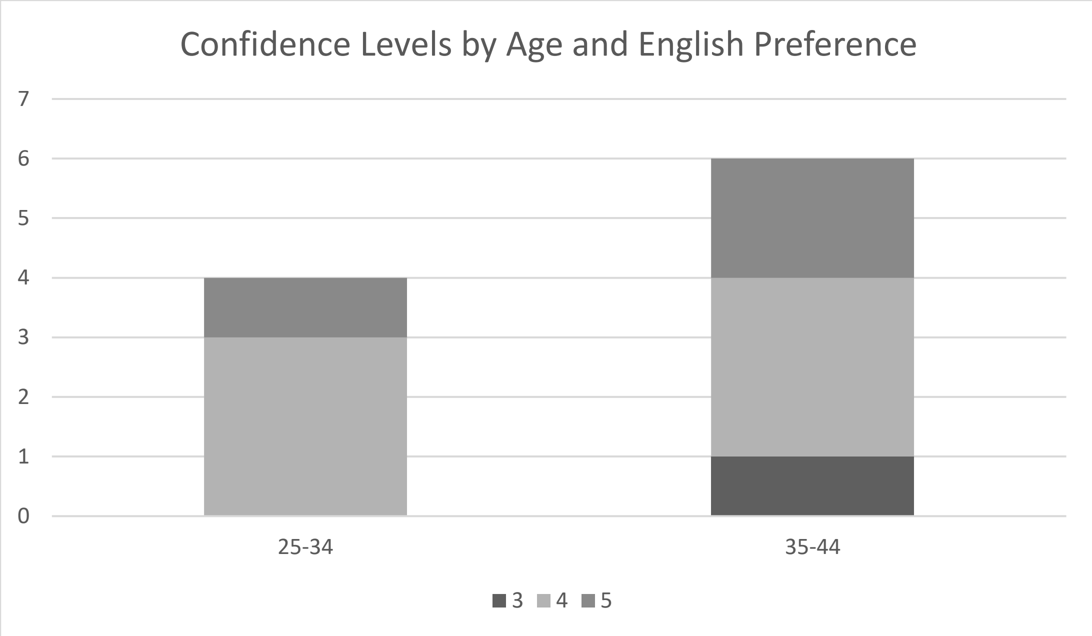

Figure 7 Confidence Levels by Age and English Preference

This indicates that their predisposition towards using the dominant science language provided sufficient understanding to participate in these activities. However, older participants who are over 65 also reported moderate confidence levels, suggesting that predisposition can benefit them over time, but it may require a more consistent engagement to gain the same level of comfort.

In contrast, activities- such as woodworking, sewing, or basic crafting showed a reduced dependency on the dominant science language. In these practical and creative domains, participants could communicate effectively in their native language, supported by visual aids and hands-on demonstrations. This meant that participants were less reliant on English proficiency when the activities were more tactile and less technical. This reduced reliance on the dominant science language was evident in participants' behaviours and preferences regarding their maker activities and interactions within the makerspace. Several interview participants expressed a strong interest in the electronics station and a desire to use or learn about its tools for their projects. However, many reported feeling intimidated or hesitant due to the increased reliance on English, particularly the technical terminology associated with using or learning about the electronics station and its activities.

Pierce also highlighted the larger pool of information available in English for technical topics, making it his preferred research language, "I get most of my research information in English only because I believe that the pool of information is larger. Not necessarily better by default, but just for ease of use and because I enjoy reading and speaking English."

Pierce’s perspective underscores how the vast availability of resources in English makes it a preferred language for conducting research on technical topics, even for non-native speakers who have a good command of English.

Troy noted that even some English-language content on YouTube and other online platforms is created by German native speakers:

> *There are quite a few projects, like specific things or YouTube channels, where you then eventually figure out that the person is actually German. So, like, I think quite a proportion of my English-speaking resources are probably created by German native speakers, actually. But that's just how the world works, I guess, that, you know, people who feel comfortable doing it in English might provide resources in English anyway, even if they're German native speakers, because it reaches a bigger community.*

This observation adds depth to the discussion on the prevalence of English resources, illustrating that many non-native English speakers still contribute content in English to reach a broader audience.

Language barriers also pose challenges for non-native English speakers. Translating specific technical terms was particularly difficult, as many English terms did not have direct equivalents in other languages. This led to participants often adopting the English terms directly when communicating with others, which made technical discussions more accessible for those who were familiar with these terms but posed challenges for those without adequate English proficiency. Ian spoke about the difficulties of communicating technical terminology in Turkish, particularly when there was not a direct equivalent for an English term:

> *Terminology has always been a struggle, especially in Turkish. Sometimes the Turkish terms just don't convey the right meaning. When presenting my projects, I often used English terminology, like 'ratchet' for a locking mechanism. I found it incredibly challenging to explain in Turkish during university jury presentations. There wasn't a direct equivalent, and my explanation fell flat*

Ian's experience highlights those direct translations of certain technical terms create challenges in effectively communicating complex concepts in his native language, particularly in academic or formal settings. This is also reflected by the survey respondents' frequency of English terminology used in makerspace projects.

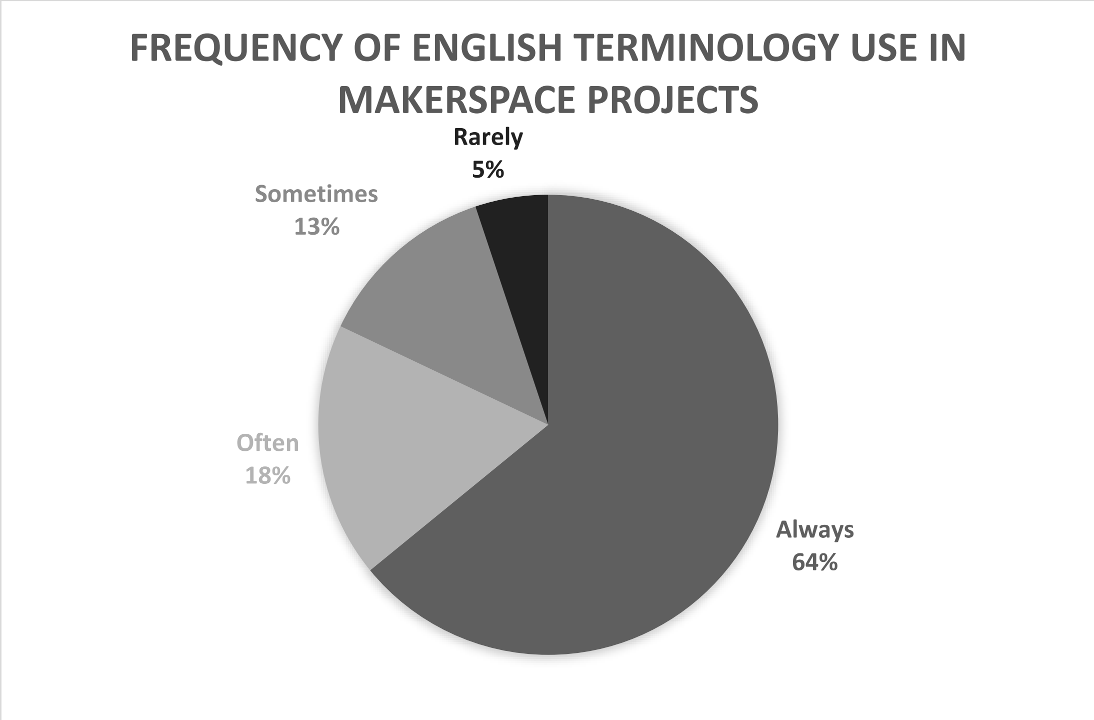

Figure 8 Frequency of English Terminology Use in Makerspace Projects

Britta also mentioned the difficulties she faced when transitioning from German to English in her academic work, especially during her master's program:

> *"When we had to read English texts there, of course, yes, it was a barrier. But then the master's was obviously in English. And the beginning was tough. They basically taught me English. So obviously it was a barrier, yes. At the beginning it was painful reading paper. I remember it was painful. I took ages to read the paper"*

This illustrates how the transition to the dominant science language was not always smooth, with significant challenges initially in accessing and understanding technical content, which impacted the learning process.

Troy highlighted the impact of language diversity, especially with English being the primary language for resources:

> *Language diversity is a difficult question because I think, certainly, it means that English-focused, like, doesn't exclude people. Like, clearly there are people for whom that's another barrier. Like, the fact that a lot of resources mostly exist in English is a barrier.*

This comment underscores the exclusivity that English creates, where individuals without sufficient English proficiency may struggle to access the same resources, making language an additional hurdle in learning and participation.

Collaboration across disciplines and cultures was another area where the influence of dominant science language became evident. English served as a common technical language that enabled effective communication among makers from diverse linguistic backgrounds. The shared use of English allowed individuals with different expertise or linguistic backgrounds to collaborate, exchange ideas, and work on complex projects together. However, while English facilitated technical learning, discussions and collaboration, it also presented challenges in terms of access and inclusivity.

In conclusion, English proficiency played a significant role in enabling participants to access global technical knowledge, particularly in complex technical domains like electronics. However, this reliance also created barriers for non-native speakers, who faced challenges in fully engaging with resources or discussions. The makerspaces community adapted to these challenges by employing multilingual strategies, using visual communication, and simplifying technical language to promote inclusivity. This ensured that, despite the dominance of English participants from different backgrounds were able to learn, collaborate and contribute to the makerspace, fostering a supportive and accessible learning environment.

4.6. Additional Survey Findings

The survey data revealed additional insights regarding age, gender and inclusivity within makerspaces. Gender disparity was evident among these revelations, with the male participants forming the majority of makerspace members.

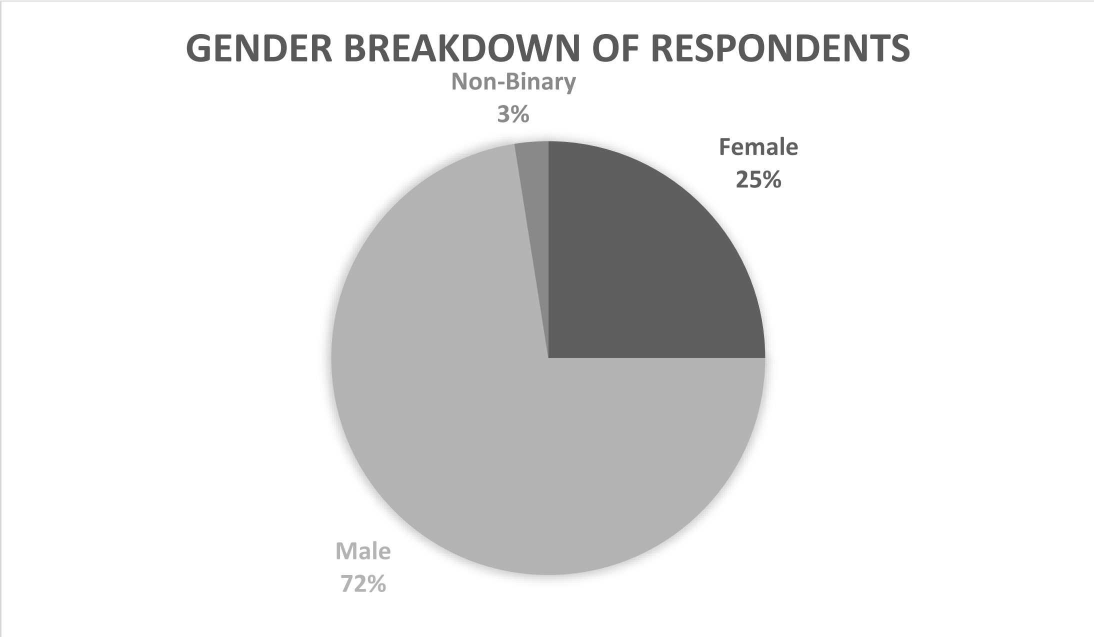

Figure 9 Gender Breakdown of Respondents

These findings indicated that non-male participants were significantly fewer, and they reported lower confidence levels, particularly in activities requiring advanced technical skills. Female and non-binary respondents were also more likely to face barriers when engaging with technical content in English.

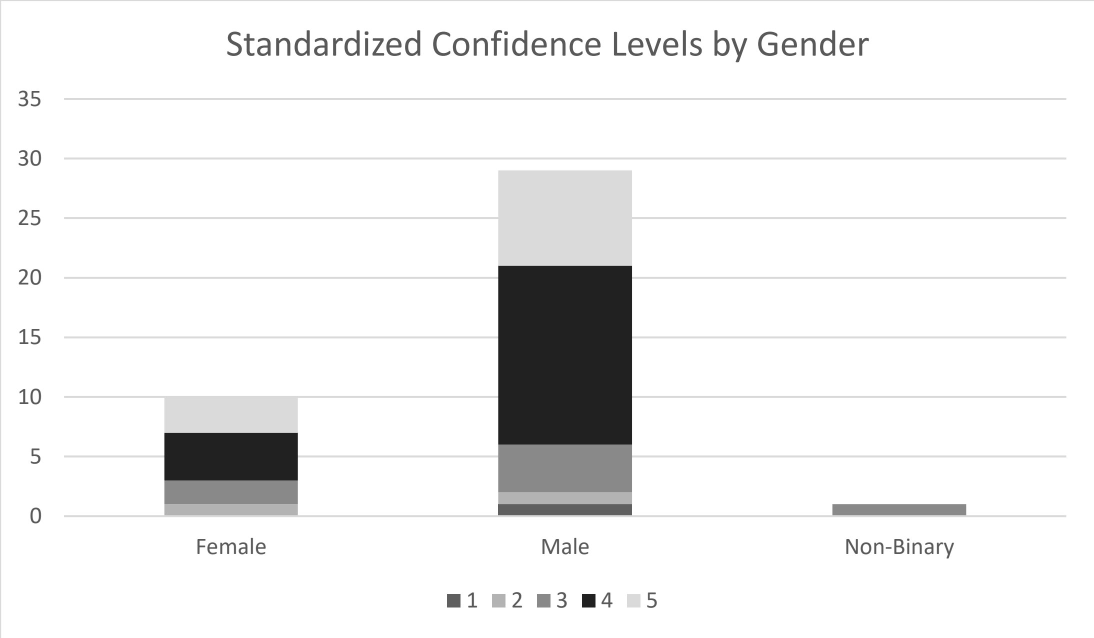

Figure 10 Standardized Confidence Levels by Gender

These barriers impacted their confidence and reduced their engagement in makerspace activities, highlighting the need for more inclusive practices.

4.7. Conclusion

The findings presented in this chapter illustrate the complex interplay between early influences, hands-on learning, community engagement, language, and communication styles in makerspaces. Participants' engagement in the making was often shaped by early exposure to hands-on activities facilitated by family members and peers, which nurtured their curiosity and technical skills. These early influences set the stage for a lifelong interest in making, which was further enriched by supportive communities and opportunities for practical experimentation.

Hands-on learning and skill development were key themes, highlighting the significance of self-directed exploration, iterative problem-solving, and leveraging online resources such as YouTube. This form of independent learning allowed participants to acquire technical skills at their own pace, while community-driven support filled gaps in knowledge through mentorship, peer collaboration and shared learning experiences. The combined approach of self-learning and communal learning fostered a resilient and resourceful maker mindset.

Community and social interactions also played an essential role in participants' learning journeys, offering emotional support, motivation, and opportunities for collaboration. The makerspace community emerged as a key factor in enabling participants to share knowledge, exchange ideas, and engage in diverse projects, thus creating a dynamic learning environment that supported both individual growth and collective advancement.

Language emerged as both a facilitator and a barrier in participants' experiences. While English proficiency enabled access to technical knowledge and global resources, non-native speakers often faced challenges in navigating complex terminology and accessing in-depth information. Participants adapted by employing visual aids, simplified language and multilingual strategies to bridge communication gaps and ensure inclusivity.

Overall, this chapter reveals that learning and engagement within makerspaces are shaped by a combination of individual initiative, social influences, community dynamics, and language adaptability. These factors work together to create an inclusive and supportive learning ecosystem where individuals are empowered to explore, experiment, and collaborate in pursuit of their creative and technical aspirations.

4.8. Summary of the Chapter

This chapter presented the findings of the research, focusing on how early influences, hands-on learning, community dynamics, language, and communication shape individuals' experiences in makerspaces. Early exposure to making activities, facilitated by family members and peers, was shown to play a foundational role in fostering participants’ curiosity, technical skills, and long-term interest in making.

Hands-on learning emerged as a critical factor, with participants emphasizing self-directed exploration, trial and error, and leveraging online resources like YouTube to acquire skills independently. This approach was complemented by the supportive environment of the makerspace community, where peer mentorship, collaborative learning, and emotional encouragement further enhanced skill development and engagement.

The findings also highlighted the influence of language, particularly English as the dominant science language, on participants’ ability to access technical knowledge and collaborate effectively. While proficiency in English provided access to global resources, non-native speakers faced challenges with technical terminology, necessitating adaptations such as visual aids, multilingual strategies, and simplified communication to promote inclusivity.

Overall, the chapter revealed the complex interplay of individual initiative, social support, and linguistic adaptability in shaping learning and engagement within makerspaces, creating a dynamic and inclusive environment for participants to explore and develop their skills.

CHAPTER 5

DISCUSSION

This chapter interprets the findings of the study by linking them to the theoretical frameworks outlined in the literature review. The analysis demonstrates how language, particularly English as the dominant science language, influences non-experts' engagement in makerspaces. The findings provide empirical support for key themes identified in the literature while extending these insights into informal learning environments like makerspaces.

The study's findings confirm the principles of linguistic relativity, as outlined in the literature review. The Sapir-Whorf Hypothesis suggests that language structures influence thought and cognition, shaping how individuals perceive and understand abstract concepts (Whorf, 1956; Sapir, 1921). Participants, particularly non-native speakers, encountered significant challenges in grasping technical terminology in English, reflecting Boroditsky's (2011) research on how linguistic structures shape cognitive processes. The dual reliance on English, alongside German in the observed makerspace, highlighted English's role as a global knowledge enabler but also its limitations. For example, Ian’s difficulty translating the term “ratchet” into Turkish underscored how linguistic disparities obstruct problem-solving. This aligns with findings from the research that indicate proficiency in English significantly impacts access to high-quality technical resources, while language barriers can slow progress.

Cognitive strain from switching between languages and translating technical terms hindered participants' comprehension and communication. These challenges validate the concept of linguistic relativity, emphasizing the need for multilingual resources and standardized terminology to reduce cognitive barriers. Survey data reinforced these findings, showing that younger participants (aged 18-34) were more comfortable navigating scientific content in English, linking proficiency to higher engagement levels with technical subjects.

Visual aids played a crucial role in overcoming linguistic obstacles. Resources such as diagrams, video tutorials, and sketches provided participants with universal tools to understand complex processes, reducing their reliance on textual explanations. These tools not only enabled participants to adapt and succeed in navigating technical projects but also became indispensable for building confidence and acquiring new skills. These findings align with participants' emphasis on visual methods, such as CNC operation guides, which bridged linguistic divides and enabled skill acquisition regardless of language proficiency.

Peer collaboration significantly amplified the benefits of visual aids. Informal knowledge-sharing networks fostered peer-to-peer learning, where participants demonstrated techniques, introduced tools, and exchanged expertise. This collaborative approach was instrumental in helping participants surmount linguistic barriers, leading to the acquisition of both technical skills and effective ways to communicate across linguistic and cultural divides. For example, mentorship roles taken on by experienced members, such as tool introductions and volunteer-driven inductions, created a supportive learning ecosystem.

The predominance of German in the observed makerspace posed challenges for non-German speakers, limiting their engagement with workshops and documentation. Conversely, English, as the dominant language in technical domains like electronics, created difficulties for German-speaking participants who lacked fluency in English. The scarcity of German-language resources in specialized fields further prompted participants to favour English for research and technical knowledge acquisition. These dynamics underscore the need for multilingual policies addressing both local (German) and global (English) linguistic demands to support diverse skill acquisition.

Despite these barriers, the collaborative ethos of makerspaces mitigated some challenges. Peer support, visual aids, and translingual practices enabled participants to engage meaningfully, aligning with the literature's emphasis on makerspaces as environments that democratize access to science and technology. Observations highlighted how peer encouragement and collaborative learning motivated participants to explore new tools and techniques, fostering confidence and skill development.

Translingual practices provided participants with dynamic tools to navigate linguistic barriers. By blending elements of multiple languages—such as combining English with their native languages or German—participants could communicate technical concepts more effectively. These approaches foster nuanced and accessible communication, as Canagarajah's (2012) translingual practice suggests.

Hands-on learning emerged as a critical strategy for overcoming language-dependent challenges. Participants emphasized trial-and-error approaches, which allowed them to engage directly with tools and processes. For instance, dismantling and reassembling mechanical devices provided insights into functional design, while iterative testing of laser-cutting projects enhanced both precision and confidence. These tactile experiences offered participants a practical understanding that transcended linguistic obstacles, fostering independence and innovation. The findings emphasize how hands-on approaches and self-directed learning enhance engagement and skill acquisition, often complemented by online resources like YouTube.

The findings of this study closely align with the theoretical insights presented in the literature review, confirming the dual role of language as both a facilitator and a barrier. By demonstrating how linguistic relativity, the dominance of English, and the dynamics of informal learning intersect, the discussion highlights the pervasive influence of language on engagement with science and technology. Through adaptive strategies, visual communication tools, translingual practices, and hands-on learning, makerspaces have the potential to bridge linguistic divides, fostering inclusivity and empowering non-experts. However, addressing structural barriers remains critical to ensuring equitable participation in these collaborative environments.

This discussion sets the stage for the subsequent chapter, which explores actionable policy suggestions aimed at mitigating these barriers and enhancing inclusivity within makerspaces. By translating these findings into practical strategies, the next chapter provides a pathway for fostering equitable access to science and technology in informal learning environments.

CHAPTER 6

POLICY SUGGESTION

Based on the findings and discussions in this study, the following policy suggestions aim to enhance the understanding and predisposition of non-native speakers toward technical and scientific subjects within makerspaces. These policies focus on practical engagement, linguistic inclusivity, and collaborative learning as foundational strategies. The following table summarises the findings, the problems they highlight, and the corresponding policy suggestions to address these issues.

Table 4 Policy Suggestions

Finding	Specific Problem	Policy Suggestion	Implementation Method
Hands-on learning overcomes language barriers.	Reliance on text-heavy instructions creates challenges for non-native speakers.	Prioritize hands-on, task-oriented workshops.	Conduct immersive workshops with guided demonstrations and iterative problem-solving approaches. Provide real-time feedback during activities.

Table 4 Policy Suggestions Continued

Multilingual resources improve accessibility.	Cognitive strain from navigating resources in English and local languages (e.g., German).	Develop bilingual or multilingual instructional materials and standardized glossaries.	Collaborate with professional translators and bilingual members to create and update manuals, signage, and project guides. Create a glossary of key technical terms in multiple languages.
Visual aids bridge linguistic divides.	Text-dependent explanations hinder understanding for diverse participants.	Incorporate detailed visual communication tools.	Establish a centralized repository of diagrams, infographics, and video tutorials. Provide video tutorials with multilingual subtitles and use universally recognizable symbols for signage.
Peer collaboration supports learning.	Informal collaboration lacks structure, limiting its impact.	Strengthen peer collaboration through structured mentorship and buddy systems.	Introduce mentorship programs pairing native and non-native speakers. Facilitate bilingual peer-led training sessions and knowledge-sharing forums.

Table 4 Policy Suggestions Continued

Translingual practices enhance communication.	Monolingual approaches restrict effective communication for multilingual participants.	Encourage translingual practices in communication.	Design workshops integrating translingual activities. Normalize code-switching and multilingual communication in makerspaces.
Technology can aid accessibility.	Limited access to tools for real-time translation and multilingual interfaces.	Leverage technological tools for translation and accessibility.	Provide access to real-time translation software and multilingual interfaces. Use Augmented Reality to overlay visual instructions in multiple languages directly onto tools or workspaces.
Balancing local and global language needs is essential.	Overemphasis on English marginalizes local languages and vice versa.	Balance local (e.g., German) and global (English) linguistic needs.	Host multilingual workshops and ensure equal availability of local and global language resources. Adopt bilingual policies reflecting principles of multilingualism.

Table 4 Policy Suggestions Continued

Simplified language improves inclusivity.	Technical jargon and complex language exclude less experienced participants.	Adopt Plain, Easy, and Accessible Language frameworks.	Simplify content using Easy Language, eliminate jargon through Plain Language, and adapt Plain Language Summaries for instructional materials. Provide visual aids to complement the simplified text.

All the policy suggestions listed in the table are discussed in detail below, with examples and implementation strategies based on the findings.

6.1. Enhancing Hands-On Learning Opportunities

Hands-on learning emerged as a critical strategy for overcoming language barriers and fostering skill acquisition. Participants who engaged directly with tools and processes were able to bypass language-heavy instructions, fostering a deeper understanding of technical concepts. Facilitators should prioritize immersive, task-oriented workshops, such as those focused on CNC machining or 3D printing, that minimize reliance on textual materials and maximize tactile and experiential learning. Real-time feedback and visual aids can further enhance comprehension and engagement during these activities. For instance, incorporating guided demonstrations and allowing iterative problem-solving approaches can help participants develop confidence and skills organically. These strategies align with Hatch’s (2014) emphasis on experimentation and the value of learning through doing.

6.2. Developing Multilingual Resources

The dominance of English in technical domains, combined with local languages such as German, created significant cognitive strain for non-native speakers in the observed makerspaces. To address this, makerspaces should develop bilingual or multilingual instructional materials, including manuals, safety guidelines, and project documentation. Collaborating with professional translators and subject-matter experts ensures technical accuracy while catering to the linguistic diversity of participants. Additionally, creating a standardized glossary of key technical terms in multiple languages would ensure consistency in terminology and provide non-native speakers with tools to navigate technical concepts confidently. This approach reflects Canagarajah's (2012) advocacy for embracing multilingual practices as a means of fostering inclusivity and collaboration.

6.3. Incorporating Visual Communication Tools

Visual aids proved indispensable in bridging linguistic divides, enabling participants to comprehend technical processes without relying heavily on text. Makerspaces should establish a centralized repository of visual resources accessible to all participants. This includes detailed diagrams, infographics, and video tutorials tailored to various proficiency levels. For example, video tutorials with multilingual subtitles can enhance the accessibility of complex processes. Visual signage, such as exploded-view diagrams or universally recognizable symbols, can provide clear guidance for tool usage and safety protocols. These measures align with Maaß and Rink's (2020) recommendations for accessible and plain language strategies.

6.4. Strengthening Peer Collaboration and Mentorship

Peer collaboration played a vital role in helping participants navigate linguistic barriers. Informal mentorships and knowledge-sharing networks within makerspaces amplified learning opportunities. To formalize these benefits, makerspaces should introduce structured mentorship programs and buddy systems that pair native speakers with non-native participants. Peer-led bilingual training sessions and facilitated knowledge-sharing forums can further strengthen this collaborative ethos. These practices align with Sheridan et al.'s (2014) emphasis on the role of community in fostering learning and innovation within makerspaces. Such initiatives not only mitigate linguistic challenges but also build a supportive and inclusive community.

6.5. Embracing Translingual Practices

The study's findings underscore the value of translingual practices in navigating linguistic challenges. Participants who blended multiple languages or employed translanguaging strategies were able to communicate technical ideas more effectively. Makerspaces should create environments where such practices are encouraged and normalized. Workshops designed to integrate translingual activities can help participants leverage their full linguistic repertoire to solve technical challenges. Promoting an acceptance of global Englishes, as highlighted by Bolton (2020), can further enhance flexibility and inclusivity in communication frameworks.

6.6. Leveraging Technology for Accessibility

Technological tools can bridge linguistic divides and enhance accessibility in makerspaces. For instance, real-time translation software and multilingual digital interfaces for tools and machinery can aid non-native speakers. Makerspaces should provide access to apps or devices that translate technical instructions into participants' preferred languages. Advanced tools like Augmented Reality applications can overlay interactive visual instructions directly onto tools or workspaces, providing step-by-step guidance in real time. These technologies reduce reliance on written or spoken language and create engaging and intuitive learning environments.

6.7. Balancing Local and Global Linguistic Needs

Balancing local language demands with the global dominance of English is essential for fostering inclusivity. Makerspaces should host multilingual workshops and ensure that both local and global language resources are equally available. For example, providing instructional materials in both German and English ensures that all participants can access and contribute to technical knowledge effectively. Adopting a bilingual policy reflects the principles of plurilingualism and recognizes the cognitive and collaborative benefits of linguistic diversity. Such practices can help makerspaces maintain their mission of inclusivity while enhancing participants' ability to engage with science and technology.

6.8. Promoting Plain, Easy, and Accessible Language Frameworks

The adoption of Plain, Easy, and Accessible Language frameworks ensures that communication materials are understandable for diverse audiences. Simplifying technical content and structuring information clearly can significantly enhance accessibility. For example, Easy Language simplifies content and incorporates visual aids to cater to participants with limited literacy or cognitive impairments (Maaß & Rink, 2020). Plain Language eliminates jargon and ensures clarity for broader usability (Petelin, 2010). Plain Language Summaries adapt techniques from scholarly publishing to create instructional materials that bridge gaps between experts and non-experts (Rosenberg et al., 2023). These frameworks form the foundation of inclusive communication strategies in makerspaces.

6.9. Conclusion

The policy suggestions outlined in this chapter emphasize practical and inclusive approaches to mitigating linguistic barriers in makerspaces. By implementing these strategies, makerspaces can create environments where participants, regardless of linguistic background, can fully engage with science and technology. These policies not only address immediate challenges but also contribute to the long-term goal of fostering equitable and innovative learning communities.

CHAPTER 7

CONCLUSION

This study, uniquely focused on non-native speakers of the dominant science language, English, within the dynamic environments of makerspaces, explored the intersection of language, cognition, and skill acquisition. Makerspaces, as hubs for informal learning and innovation, provided an ideal context to examine how linguistic dynamics influence individuals' understanding, engagement, and predisposition toward scientific and technological concepts.

The findings of this research align with the core tenets of linguistic relativity, highlighting that language is not merely a communication tool but a cognitive framework that shapes how individuals approach and interpret technical challenges. The dominance of English as the dominant science language presented dual implications: while it enabled access to global technical knowledge, it simultaneously imposed significant cognitive burdens on non-native speakers, particularly when compounded by local linguistic dominance, such as German in the observed makerspace.

7.1. Key Findings

Participants often relied on visual aids and hands-on learning to mitigate language barriers, emphasizing the universal appeal and accessibility of tactile engagement and visual representation in technical skill-building. These tools, coupled with collaborative peer networks, fostered an environment where language-related challenges were addressed through shared knowledge and experiential learning. The cognitive strain of language-switching, vividly illustrated through participant anecdotes, underscored the need for multilingual resources and translingual practices to reduce barriers and enhance inclusivity.

Moreover, the observed interplay between German and English within the makerspace revealed nuanced dynamics of inclusion and exclusion. German was the primary language for workshops and documentation, often alienating non-German speakers, while English was indispensable for accessing broader technical resources, occasionally disadvantaging German speakers. This duality underscored the importance of multilingual strategies to bridge local and global linguistic gaps, ensuring equitable access to knowledge and participation.

7.2. Implications

This study underscores the practical implications of language in shaping scientific and technological engagement. For non-native speakers, the ability to navigate multiple linguistic frameworks was found to be essential for both technical understanding and active participation in collaborative projects. The findings suggest that makerspaces must adopt practical strategies to foster linguistic inclusivity, including developing multilingual resources, integrating visual and experiential learning methods, and promoting peer-led collaborative networks.

The concept of translingual practice, as proposed by Canagarajah (2012), emerged as a valuable framework for addressing linguistic diversity in makerspaces. By enabling participants to draw on their entire linguistic repertoire, makerspaces can transform language from a barrier into a tool for innovation and collaboration. This approach enhances individual learning and enriches the collective creative process, as diverse linguistic perspectives contribute to more innovative problem-solving.

7.3. Future Directions

The findings of this research open avenues for further exploration and emphasize the need for continued research in this area. Comparative studies across different cultural and linguistic contexts could provide deeper insights into how language influences skill acquisition and innovation in various makerspaces globally. Additionally, investigating the broader applications of these findings in other informal learning environments, such as libraries or community centres, could yield valuable strategies for democratizing access to science and technology.

7.4. Limitations

This study had several limitations that should be acknowledged. The small sample size, comprising nine interviewees and 41 survey responses, restricted the generalisability of the findings. The use of convenience sampling for the survey and the focus on a single makerspace limited the applicability of the results to broader contexts. Additionally, the short duration of ethnographic observation may not have fully captured the range of activities and interactions within the makerspace.

While the study explored language barriers, it primarily included participants who were already engaged with English to some extent. Hence, the experiences of those who were entirely excluded due to language barriers may have remained underrepresented. Moreover, the reliance on surveys and interviews, which depended on participants' self-perceptions, introduced the possibility of bias and may have limited the accuracy of reported experiences.

Despite these limitations, the study offered noteworthy insights into the role of language in shaping the participation and engagement of non-expert individuals in scientific and technological activities and makerspaces.

7.5. Concluding Remarks

This thesis contributes to the growing knowledge of the relationship between language, cognition, and engagement in science and technology. Examining non-native speakers' experiences in makerspaces highlights the critical importance of linguistic inclusivity in fostering equitable access to knowledge and innovation. Through thoughtful design and implementing multilingual policies, makerspaces can better serve as inclusive environments where individuals from diverse linguistic and cultural backgrounds feel empowered to learn, create, and collaborate. These insights enhance our understanding of linguistic dynamics in informal learning settings and provide actionable recommendations to support the broader goals of inclusivity and equity in science and technology.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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16 AĞUSTOS 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Dr. Öğr.Üyesi Arsev Umur AYDINOĞLU

Danışmanığını yürüttüğünüz Mert AKOL'un ***"Baskın Bilim Dilini Anadili Olarak Konuşan Bireylerin Bilim ve Teknoloji Alanlarındaki Yatkınlarının Makespace Tecrübeleri Üzerinden İncelenmesi"*** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek **0382-ODTUİAEK-2023** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan

Prof.Dr. İ. Semih AKÇOMAK
Üye

Doç. Dr. Ali Emre Turgut
Üye

Doç. Dr. Şerife SEVİNÇ
Üye

Doç.Dr. Murat Perit ÇAKIR
Üye

Dr. Öğretim Üyesi Süreyya ÖZCAN KABASAKAL
Üye

Dr. Öğretim Üyesi Müge GÜNDÜZ
Üye

Figure 11 Approval of The METU Human Subjects Ethics Committee

B. SEMI-STRUCTURED INTERVIEW QUESTIONS AND RATIONALE

This appendix outlines the semi-structured interview questions used in this study, along with the rationale and goals for each. These questions were designed to explore participants' experiences, focusing on language use, collaboration, and engagement in makerspaces.

Interview Questions:

- Can you tell me a bit about yourself and your involvement in the makerspace? How long have you participated, and what initially attracted you to this space?

Gather basic background information about the participant's involvement in the makerspace, their motivation for joining, and their level of engagement.

- Can you provide some insights into your background and educational/professional experiences contributing to your engagement in the makerspace?

Understand the influence of participants' educational and professional experiences on their makerspace activities.

- How would you describe your level of experience in the makerspace? Are you a beginner, intermediate, or advanced maker?

Assess participants' self-perceived skill levels to contextualize their experiences and language-related challenges.

- How do you access new information when needed for your activities as a maker? Which languages do you prefer?

Explore participants' learning strategies and language preferences, identifying potential barriers to accessing knowledge.

- Have you participated in any makerspace activities, workshops, or collaborative projects? If so, could you share your experiences and what you gained from those engagements?

Understand how structured makerspace activities contribute to participants' learning and collaboration experiences.

- Are there any specific areas or skills within the makerspace that you are looking to develop further or explore?

Identify participants' learning goals and whether language acts as a barrier or facilitator in their skill acquisition.

- Can you describe any collaborative projects or group activities you have been involved in within the makerspace? What role did you play, and what did you learn from these experiences?

Explore how participants' collaborative experiences are shaped by language and communication dynamics.

- Are there any future projects or goals you plan to pursue within the makerspace? What are you most excited about in terms of your future involvement?

Assess participants' aspirations and how language influences their planning and engagement in future makerspace activities.

- Can you describe one of your projects, new or previous, with as much detail as possible, in both English and/or your native language?

Examine participants' comfort and proficiency in explaining technical concepts in multiple languages.

- Can you share any experiences or instances where language barriers have impacted your interaction or communication within the makerspace environment?

Identify specific challenges participants face due to language barriers and their strategies for overcoming them.

- How do you feel language barriers affect collaboration and knowledge sharing among makerspace participants or makers?

Gather participants' perceptions of how language influences teamwork and community dynamics.

- Have you noticed any strategies or approaches used by makerspace participants to overcome language barriers? If so, could you describe them?

Document effective practices for navigating language challenges within the makerspace.

- How do you navigate the language barrier when communicating with other makers or seeking assistance within the makerspace community? Are there any strategies or tools that you use to overcome these challenges?

Explore participants' personal strategies for addressing language-related challenges.

- In your experience, how does language diversity or multilingualism within the makerspace community contribute to a richer and more inclusive environment? Are there any specific instances where language differences have resulted in unique collaborations or learning opportunities?

Highlight the positive aspects of linguistic diversity in fostering creativity and inclusivity.

- Can you share any personal anecdotes or experiences that highlight the impact of language on your involvement in the makerspace or your interactions with the wider maker community?

Collect detailed stories that illustrate how language influences participants' makerspace experiences.

- Is there anything else you would like to add or discuss?

Provide participants with an opportunity to share additional insights or perspectives not covered in the previous questions.

C. SURVEY QUESTIONS AND RATIONALE

This appendix provides a detailed breakdown of the survey questions used in this study, categorized by sections, along with the rationale for each. These questions were designed to explore participants' experiences with language in makerspaces, focusing on demographics, habits, language preferences, and the influence of the dominant science language.

Demographic Information

The first section of the survey was aimed at determining the respondents' demographics:

- The responder's age
- Gender
- Level of education
- Educational background
- Professional background
- Native language
- Other languages they speak fluently

This section gathers foundational data to contextualize the responses. Questions on age and gender address inclusivity concerns within makerspaces. Questions on language proficiency establish a baseline for understanding language-related challenges.

Makerspace Usage Habits

This section gauges the respondents' habits and levels of experience in makerspaces:

- How frequently do you participate in makerspace or maker activities?
- Which stations do you use the most in the makerspace? (Select all that apply)
- How confident do you feel when working on projects in the makerspace?
- How satisfied are you with the outcomes of your projects in the makerspace?

These questions assess the frequency and nature of makerspace engagement, confidence levels, and satisfaction with project outcomes, offering insights into how language barriers may influence these factors.

General Understanding of Science and Technology

This section measures participants' baseline understanding and engagement with science and technology:

- How would you rate your general understanding of science and technology?
- How often do you read or engage with science and technology content (articles, videos, podcasts, etc.)?
- How often do you encounter language barriers when accessing knowledge related to science and technology?

The goal is to understand participants' familiarity with technical concepts and the frequency of encountering language barriers outside makerspaces, which might impact their engagement within these spaces.

Accessing Knowledge and Language Preferences

This section explores how respondents access and prefer to engage with knowledge:

- How do you typically access knowledge related to science and technology? (Select all that apply)

- What is your preferred language for engaging with content related to science and technology?

- In what language do you primarily access knowledge related to science and technology?

- How often do you encounter language barriers when accessing knowledge related to science and technology?

- To what extent do you agree with the statement: "Accessing knowledge in my preferred language enhances my understanding of science and technology."

- How would you rate your overall ability to understand technical content in English compared to your native language? (Skip if English is your native language.)

These questions examine the role of language preferences and barriers in shaping access to technical knowledge, emphasizing the interplay between language proficiency and understanding.

Language and Communication in Makerspaces

This section assesses how language influences communication and project work in makerspaces:

- How often do you need to use English terminology while working on projects in the makerspace?
- To what extent do you agree with the statement: "I find it challenging to understand technical instructions in English while working in the makerspace."
- How comfortable are you discussing your project ideas and receiving feedback in English within the makerspace?
- How often do you rely on visual aids (e.g., diagrams, videos) to understand project instructions due to language barriers?
- To what extent do you agree with the statement: "Language differences have led to misunderstandings or mistakes in my projects within the makerspace."
- How often do you collaborate with other non-native English speakers in the makerspace?

These questions focus on how language barriers manifest in communication and collaboration within makerspaces, identifying strategies participants use to overcome these challenges.

Impact of Language on Learning and Engagement

- This section explores how language affects participants' learning experiences:
- How has the use of English as the dominant science language affected your learning experience in the makerspace?

- To what extent do you agree with the statement: "I feel that my native language would make it easier to grasp complex scientific concepts." (Skip if English is your native language.)

- How often do you participate in makerspace activities specifically designed to accommodate non-native English speakers?

- How has participating in makerspace activities influenced your proficiency in English? (Skip if English is your native language.)

These questions evaluate the role of English as the dominant science language in shaping learning outcomes and the potential benefits of activities tailored to non-native speakers.

Influence of the Dominant Science Language

This section examines the impact of English terminology on discussions and learning:

- How comfortable are you using English terminology while speaking in your native language in the makerspace?

- How often do you use English technical terms when discussing projects in your native language?

- To what extent do you agree with the statement: "Using English terminology while speaking my native language makes it easier to communicate technical concepts."

- How often do you encounter difficulties when integrating English terminology with your native language?

- How confident are you in understanding English terminology related to your projects?

- How often do you feel that using English terminology helps clarify your ideas to others who speak your native language?
- How often do you need to explain or translate English terminology to peers who speak your native language?
- To what extent do you agree with the statement: "Using English terminology in my native language discussions enhances my collaboration with others."
- How has using English terminology affected your learning and understanding of makerspace activities?
- To what extent do you agree with the statement: "English terminology is essential for accurately describing my makerspace projects."
- How often do you feel that using English terminology improves the quality of your projects?

This section evaluates the dual role of English in aiding and complicating communication, collaboration, and learning in makerspaces.

Open-ended Questions

Participants were invited to elaborate on their experiences with language in makerspaces:

- Can you describe an instance where using English terminology significantly improved your understanding or the outcome of a project?
- What challenges do you face when integrating English terminology with your native language in the makerspace?
- What benefits do you see in using English terminology while communicating in your native language within the makerspace?

- What suggestions do you have for improving the use of English terminology in native language discussions in makerspaces?

- Can you provide an example of a project where using your native language significantly improved your understanding or outcome?

- What specific aspects of makerspace activities do you find easier when conducted in your native language compared to English?

- What recommendations do you have for makerspaces to better support non-native English speakers based on your experiences?

- Is there anything else you would like to add?

The open-ended questions allow participants to provide detailed, personal insights into their language-related challenges and successes. These responses complement quantitative data and offer rich qualitative perspectives to inform recommendations.

D. CODES AND CLUSTERS

This appendix provides a detailed breakdown of the codes and clusters used in the qualitative data analysis. These codes were developed to categorize and interpret themes related to language, learning, collaboration, and community dynamics in makerspaces.

Language and Communication Cluster

Focuses on how language barriers and visual tools impact learning and making processes.

Codes:

- Language as a Barrier: Challenges translating technical concepts between different languages and lack of standardized terms.
- Multilingual Navigation: Strategies to switch between English, German, Turkish, etc., based on context and the impact of language on knowledge access.
- Terminology Consistency: Inconsistencies in terminology across different languages and sectors, adapting terminology when collaborating across fields.
- Visual Language: Use of sketches, diagrams, and catalogues to bridge communication gaps; preference for visual over verbal communication when conveying technical ideas.
- Dominance of English: Reliance on English for learning, research, and communication within the maker community; limited resources in Turkish, making English the go-to language for technical knowledge.

Self-Learning and Skill Acquisition Cluster

Addresses individual learning journeys, the use of digital tools, and sharing knowledge.

Codes:

- Learning and Experimentation: Self-teaching through trial and error, online tutorials, and independent research, with emphasis on iterative skill development and knowledge-building.

- Knowledge Sharing and Tutorials: Creating and sharing tutorials to fill gaps in available technical resources; the role of tutorials in enabling less experienced makers to access complex knowledge.

- Documentation for Learning: Using catalogues, guides, and other resources for learning; the value of creating bilingual manuals for easy comprehension and accessibility.

- Motivations for Learning: Personal motivations such as curiosity, passion, practicality, or personal interests; the influence of educational background on maker activities.

- DIY Enthusiasm: Enthusiasm for DIY projects, including making personal toys, cooking experiments, and crafting unique projects; viewing everyday activities, such as cooking or home projects, as part of the maker experience.

Community and Makerspace Engagement Cluster

Explores the dual role of makerspaces as both communal and individualistic spaces, including gender dynamics.

Codes:

- Community Dynamics in Makerspaces: Makerspace as a communal hub while providing room for independent making; Slack as a platform for maintaining a sense of community when not physically present in the makerspace.
- Makerspace Culture and Dynamics: Explores the general culture of makerspaces, including community interactions, individual motivations, and engagement.
- Access and Barriers in Makerspaces: Limitations in accessing tools, financial constraints, and barriers to executing digital concepts as physical prototypes; makerspaces as an important resource despite certain access challenges.
- Skill Level Perception: Perceived skill levels, whether as beginners, intermediate, or advanced; differences in comfort levels with tools and technologies and how individuals evaluate their skill growth over time.

Cluster: Practical Projects and Problem-Solving Cluster

Focuses on hands-on projects, collaboration with craftsmen, and overcoming project challenges.

Codes:

- Hands-On Making: Various projects involving tools like 3D printers, CNC, and laser cutters and their role in realizing personal concepts; focus on building and crafting from childhood to adulthood.

- Collaboration and Crafting Communication: Differences in communicating with makers vs. crafters; adapting explanations to fit different levels of familiarity with technical concepts; challenges in conveying digital design concepts in the physical workshop.

- Practical Problem Solving: Iterative and hands-on problem solving as a part of practical making; the importance of digital tools for improving precision in physical projects and overcoming manual errors.

Motivations and Psychological Aspects Cluster

Captures motivations, intrinsic rewards, and the role of makerspaces in fulfilling personal needs.

Codes:

- Intrinsic Motivation: Joy of creating, sense of curiosity, and exploration as core motivations; autonomy and control over projects as driving forces for maker activities.
- Psychological Need for Space: Makerspaces as environments for personal space and respite from everyday responsibilities; the emotional and psychological benefits derived from making in a quiet, personal environment.
- Making as a Lifestyle: Viewing activities like cooking and crafting as integral parts of the maker mindset; a lifestyle of exploring, learning, and creating in both digital and physical forms.

E. TURKISH SUMMARY / TÜRKÇE ÖZET

Bu tez, baskın bilim dili olarak İngilizce'nin, uzman olmayan bireylerin bilim ve teknolojiye katılımını, bu alanlara erişimlerini ve bu alanlardaki kavrayışlarını nasıl etkilediğini kapsamlı bir şekilde incelemektedir. Almanya'daki makerspace katılımcıları üzerine odaklanarak, dilsel görelilik (Sapir-Whorf Hipotezi) ve dil bariyerlerinin bireylerin bilimsel ve teknolojik kavrayışları üzerindeki bilişsel ve pratik etkilerini ele almaktadır. Araştırma, anadili İngilizce olmayan bireylerin bilimsel bilgiye erişim süreçlerinde karşılaştıkları güçlükleri ve bu güçlükleri aşmak için geliştirdikleri stratejileri anlamayı amaçlamaktadır.

7.6. Çalışmanın Arka Planı ve Konusu

Dil, yalnızca iletişim aracı değil, aynı zamanda bireylerin bilimsel ve teknolojik konseptleri anlamalarında belirleyici bir faktördür. İngilizce, bilimde baskın dil olarak, anadili İngilizce olan bireylere kavramsal bir avantaj sağlamaktadır. Buna karşılık, anadili İngilizce olmayan bireyler, bilimsel terminoloji ve karmaşık kavramları anlamakta zorluk çekebilir, bu da onların bilimsel etkinliklere katılımını sınırlayabilir. Bu durum özellikle makerspaceler gibi iş birliğine dayalı, resmi olmayan öğrenme ortamlarında önem kazanmaktadır.

Makerspaceler, bireylerin farklı beceriler geliştirdiği, iş birliği yaptığı ve yenilikçi projeler üzerinde çalıştığı topluluk merkezli alanlardır. Bu alanlar, bilimsel bilgiye erişimin ve teknolojik faaliyetlere katılımın nasıl gerçekleştiğini incelemek için ideal bir ortam sunar. Araştırma, bu bağlamda, dilin bireylerin bilimsel ve teknolojik faaliyetlerdeki rollerini nasıl şekillendirdiğini anlamayı hedeflemiştir.

7.7. Araştırmanın Yöntemleri ve Kapsamı

Araştırma, Almanya'nın Freiburg kentinde bulunan Freilab adlı bir makerspace'te gerçekleştirilmiştir. Bu mekân, çok uluslu ve çok dilli bir topluluk yapısına sahip olması nedeniyle seçilmiştir. Araştırma sürecinde etnografik gözlemler, yarı yapılandırılmış görüşmeler ve anketlerden oluşan bir karma yöntem yaklaşımı benimsenmiştir:

- Etnografik Gözlemler: Freilab'daki kullanıcıların bilimsel ve teknolojik projelerde dil kullanımını ve etkileşimlerini anlamak amacıyla bir hafta boyunca gözlemler yapılmıştır.

- Yarı Yapılandırılmış Görüşmeler: Makerspace kullanıcılarından oluşan dokuz kişiyle derinlemesine görüşmeler gerçekleştirilmiştir. Katılımcıların yaş, dil becerileri ve kültürel geçmişleri çeşitlilik göstermektedir.

- Anketler: 41 katılımcıdan elde edilen anket verileri, kullanıcıların dil tercihleri, iş birliği deneyimleri ve dilin öğrenme süreçlerine etkisi hakkında ek bilgiler sağlamıştır.

7.8. Bulgular

Araştırmanın temel bulguları şu şekilde özetlenebilir:

Dil Avantajları ve Bariyerleri: İngilizce, bilim ve teknoloji terminolojisine erişim açısından anadili İngilizce olanlara belirgin bir avantaj sağlarken, anadili İngilizce olmayan bireyler dil bariyerleri nedeniyle zorlanmaktadır. Özellikle teknik terimler, anadili İngilizce olmayan katılımcılar için öğrenme sürecini yavaşlatabilmektedir.

Uyum Stratejileri: Anadili İngilizce olmayan bireyler, bu bariyerleri aşmak için çeşitli stratejiler geliştirmiştir. Bu stratejiler arasında görsel desteklerin kullanımı, akran iş birliği, çevrimiçi çok dilli kaynaklara erişim ve sadeleştirilmiş açıklamalar bulunmaktadır.

Topluluk Dinamikleri ve Katılım: Makerspacelerde topluluk dinamikleri ve sosyal etkileşim, bireylerin öğrenme ve katılım süreçlerini olumlu yönde etkilemektedir. Katılımcılar, iş birliğine dayalı öğrenme süreçlerinde hem bilgi paylaşımı yapmakta hem de destek almaktadır.

Bilimsel ve Teknolojik Kavrayış: Dil, bilimsel kavrayış üzerinde hem bir araç hem de bir engel olarak rol oynamaktadır. Dil yeterliliği, bireylerin bilimsel konseptleri anlamalarını ve projelere katılımlarını doğrudan etkilemektedir.

7.9. Öneriler ve Sonuçlar

Araştırma, dil bariyerlerini azaltarak ve dilsel çeşitliliği teşvik ederek makerspacelerde daha kapsayıcı bir ortam yaratılmasını önermektedir. Bu kapsamda öneriler şu şekilde sıralanmıştır:

- Çok dilli kaynakların geliştirilmesi,
- Görsel desteklerin eğitim materyallerine entegre edilmesi,
- Akran iş birliğini teşvik eden mentorluk programlarının oluşturulması,
- Yerel ve küresel ihtiyaçları dengelemek için çift dilli politikaların benimsenmesi.

Araştırma, dilin bilimsel bilgiye erişim ve bireysel katılım üzerindeki kritik rolünü vurgulayarak, daha adil ve kapsayıcı öğrenme ortamlarının tasarlanması gerektiğini ortaya koymaktadır. Tezin bulguları, yalnızca makerspaceler için değil, aynı zamanda diğer resmi olmayan öğrenme ortamları için de fikir sunmaktadır.

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