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BSc in Computer Science

A CREATIVITY BASED GOAL MODELING APPROACH FOR ACCESSIBILITY OF NEURODIVERGENT INDIVIDUALS

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Abstract

Equality and equity for all kinds of people are fundamental human rights. One movement that strives for those rights in the context of neurological differences is neurodiversity. It's a term that represents the acceptance and respect of diverse neurological conditions, such as ASD (Autism Spectrum Disorder), ADHD (Attention Deficit Hyperactivity Disorder), Dyslexia, and others, like any other human differences that distinguish us all. Such a topic points to the importance of embracing these differences in society. However, this is still a distant reality. Neurodivergents are often victims of stigma and prejudice in a world that excludes those that don't fit a strict definition of "normal", making this group prone to unemployment or lower levels of education.

Despite the difficulties that those within the neurodiversity community face, be it from their own condition or society's neurotypical prevalence, the same characteristics that distinguish them from everyone else can also be beneficial and valuable to the workplace. This can be from not only an inclusive perspective but also competition-wise, as they can bring their unique skills and innovation when aligned with their interests.

When it comes to computer science, neurodivergents, especially those with ASD, are quite attracted to this area of engineering as a career option. This dissertation will bring focus to software engineers who are neurodivergent with the goal of making some requirements engineering tasks more accessible to them. Through a systematic literature review, we understood what research has been done to tackle neurodiversity in the context of software engineering, and used it as a basis for our neurodivergent-inclusive creativity-based goal modeling approach.

The proposed solution resulted in an accessible tool for neurodivergent software engineers that covers the requirements elicitation and requirements analysis tasks while respecting Human-Computer Interaction guidelines for neurodivergent individuals. The resulting approach covers the struggles that neurodivergent engineers face when using engineering tools, while also addressing one of the core strengths found in neurodivergency, that being creativity. To achieve this, the approach bases on creativity techniques along with an iStar extension that facilitates the translation of ideas generated from those techniques to standard iStar elements. We applied the concepts of the approach to develop

the prototype of a neurodivergent-inclusive tool called IdeaStar.

The concepts of the approach along with the IdeaStar tool were empirically evaluated with respect to usefulness and ease of understanding by a group of 25 participants and the results were positive.

Keywords: software engineering, requirements engineering, goal modeling, creativity, neurodiversity, autism, ADHD, dyslexia, accessibility, inclusivity

Resumo

Igualdade e equidade para todos são direitos humanos fundamentais. Um movimento que luta por esses direitos no contexto das diferenças neurológicas é a neurodiversidade. É um termo que representa a aceitação e respeito de diversas condições neurológicas, como TEA (Transtorno do Espectro Autista), TDAH (Transtorno de Déficit de Atenção e Hiperatividade), Dislexia, entre outras, como qualquer outra diferença humana que nos distingue a todos. Tal tema aponta para a importância de acolher essas diferenças na sociedade, porém, essa ainda é uma realidade distante. Os indivíduos neurodivergentes são frequentemente vítimas de estigma e preconceito num mundo que exclui aqueles que não se enquadram numa definição estrita de "normal", tornando aquele grupo propenso ao desemprego ou a níveis de escolaridade mais baixos.

Apesar das dificuldades que os membros da comunidade da neurodiversidade enfrentam, seja por sua própria condição ou pela prevalência de neurotípicos da sociedade, as mesmas características que os distinguem de todos os outros também podem ser benéficas e valiosas para o local de trabalho. Isso pode ser de uma perspectiva não só inclusiva, mas também competitiva, pois podem trazer desempenho e inovação quando alinhados aos seus interesses.

Os neurodivergentes, especialmente aqueles com TEA, são muito atraídos pela área de ciência da computação. Esta dissertação focar-se-á nos engenheiros de software neurodivergentes, com o objetivo de lhes tornar as tarefas de engenharia de requisitos mais acessíveis. Uma revisão sistemática da literatura permitiu-nos compreender quais são as pesquisas feitas para abordar a neurodiversidade no contexto da engenharia de software. Este conhecimento foi usado como base para nossa abordagem de modelação de obejtivos inclusiva neurodiversa baseada na creatividade.

A solução proposta inclui uma ferramenta para engenheiros de software neurodivergentes para as actividades de elicitação e análise de requisitos, respeitando as diretrizes de interação-pessoa-máquina para indivíduos neurodivergentes. A solução tem em atenção as dificuldades dos engenheiros neurodivergentes quando usam ferramentas de engenharia, abordando também uma das principais características positivas encontradas na neurodivergência: a creatividade. Assim, a solução baseia-se em técnicas de criatividade

que foram utilizadas para criar uma extensão da linguagem iStar que facilita a tradução de ideias geradas por esas técnicas para elementos padrão de iStar. As ideias foram implementadas no protótipo IdeaStar.

Os conceitos da solução em conjunto com a ferramenta IdeaStar foram empiricamente avaliados por um grupo de 25 participantes e os resultados foram positivos.

Palavras-chave: engenharia de software, engenharia de requesitos, modelação de objetivos, criatividade, neurodiversidade, autismo, TDAH, deslexia, acessibilidade, inclusividade

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1

Introduction

1.1 Context and motivation

Neurodiversity, as defined by Harvard Health, refers to the cognitive diversity of all individuals, namely, those with neurological conditions such as Autism Spectrum Disorder (ASD), Dyslexia, or Attention Deficit Hyperactivity Disorder (ADHD). It presents the idea that there are different ways of thinking within those cognitive conditions that should be treated as such, instead of being seen as a deficiency [12]. This term was coined in the 1990s by sociologist Judy Singer, who herself is diagnosed with Asperger syndrome [80]. The most recent statistics estimate that around 15 to 20 percent of the world population has some form of neurodiversity [21]. There is still a lot of work to do to make these individuals more represented in society, especially in the workplace, since about 75-85% of diagnosed autistic graduates are either under-employed or unemployed [77]. Therefore, we need to do more and develop solutions that can help neurodivergent people be more present in the same workplaces that neurotypicals have flourished in for a long time. Considering their way of thinking, they can bring their special skills as a competitive advantage to companies [68].

There has been research that points out to the fact that, as an example within the various neurodivergent conditions, people diagnosed with ASD are attracted to interactions with computers [89] and that they are more likely to follow studies in STEM majors [24]. Within those STEM majors, Computer Science has the biggest representation for ASD students when compared to other majors [93]. It is then reasonable to think about how the lives of these future computer science engineers should have the necessary tools to not only adapt to their unique ways of thinking to make them more comfortable but to also help amplify their specific skills.

This is where Software Engineering (SE) comes in. Defined by the IEE Standard 610.12-1990 as "*The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software*" [38], SE includes various tasks, such as Requirements Elicitation or Modelling. Since these tasks are important steps in software creation to guarantee **usable** and **accessible** products/services,

it is fundamental to improve and/or develop accessibility and inclusivity options to those engineers within the neurodiversity community for SE tasks, which will be our motivating challenge driving this thesis.

1.2 Problem statement

After the analysis of the findings from our systematic review, we define our problem statement as the **lack of existing usable and accessible Software Engineering approaches and tools for neurodivergent software engineers to do tasks such as Requirements Engineering or Modeling**. The following section identifies the main problem, the challenges that come with it, and finally the objectives for the thesis.

Problem 1: The lack of knowledge when addressing neurodivergent inclusivity issues in the context of Software Engineering tasks.

Problem 2: The lack of existing usable and accessible Software Engineering approaches and tools for neurodivergent software engineers to do tasks such as Requirements Engineering or Modeling.

There has been a rise in interest in research about neurodivergent conditions and, consequently, in the making of accessible software [51]. This ranges from a neurodivergent individual using said software (e.g., [55, 76]) or to the developers making them (e.g., [16]). There's even been research done specifically on the effects that the neurodivergents' conditions have on their job as software engineers (e.g., [60]). These points will be discussed later on in Chapter 3. However, this is still a very small sample of research when looking at the topic in general, especially since most papers revolve around children and not working adults [11]. From the bibliography that we gathered on software engineering and neurodivergent individuals, we were not able to find any sources that focused on the accessibility of software engineering tasks to those individuals, showing a general lack of knowledge in tackling neurodiversity in this context.

Challenge 1: Characterize the current state of the art

Our first big challenge regarding the problem we set previously is to define the state of the art of techniques and tools that are used to make accessible software to neurodivergent individuals and their lives as software engineers and find links between them. The purpose of linking these two threads is to find common ground where we can find, in the case of articles about neurodivergent software engineers, approaches that could also be applied in software applications. To achieve a comprehensive view of the present state of the art, we performed a systematic literature review, as shown in chapter 3.

Challenge 2: Investigate how neurodivergents' condition affects their usage of everyday software applications and their lives as software engineers

To extend or develop new tools that are accessible to neurodivergent individuals, we need to understand in what ways their condition affects the usage of applications that are not developed with them in mind. For our topic in specific, it will also be important to consider how their way of thinking is unique in the context of those who have studied or worked as software engineers when compared to a neurotypical way of thinking. Ideally, we want to find out what to take note of to accommodate their possible shortcomings but also at the same time take advantage of their unique skills that can be useful for software engineering tasks. To do this we resort to the results found in the systematic review presented in this paper.

Challenge 3: Tie both ends of the topics referred to in challenge 2 to design a new/extension of an existing tool to accommodate neurodivergent engineers in software engineering tasks

By taking the information from both topics and connecting them, we hope to achieve the necessary information to create a new/make an extension of an existing tool for software engineering tasks that can help neurodivergent individuals become the best software engineers they can be. The developed tool must be accessible to neurodivergent individuals and comply with the standard rules set by the computer science community without any limitations in such a way that the artifact produced by the said tool is as expected with any other used in the industry. This will be the main challenge of this thesis.

1.3 Objectives

The main objective of this thesis is to propose an approach to facilitate requirements elicitation and analysis for neurodivergent individuals, such as those with ASD, ADHD, and Dyslexia.

We aim to find and evaluate techniques or methodologies that can help us address neurodiversity accessibility issues in the requirements engineering task for software development through a systematic review of said topic.

We want to bring an approach that not only takes into consideration accessibility issues but also brings a more inclusive approach that makes neurodivergent individuals feel more like active members in their work. To do this, we will identify and leverage their unique skills that could be considered strengths in the field of software engineering.

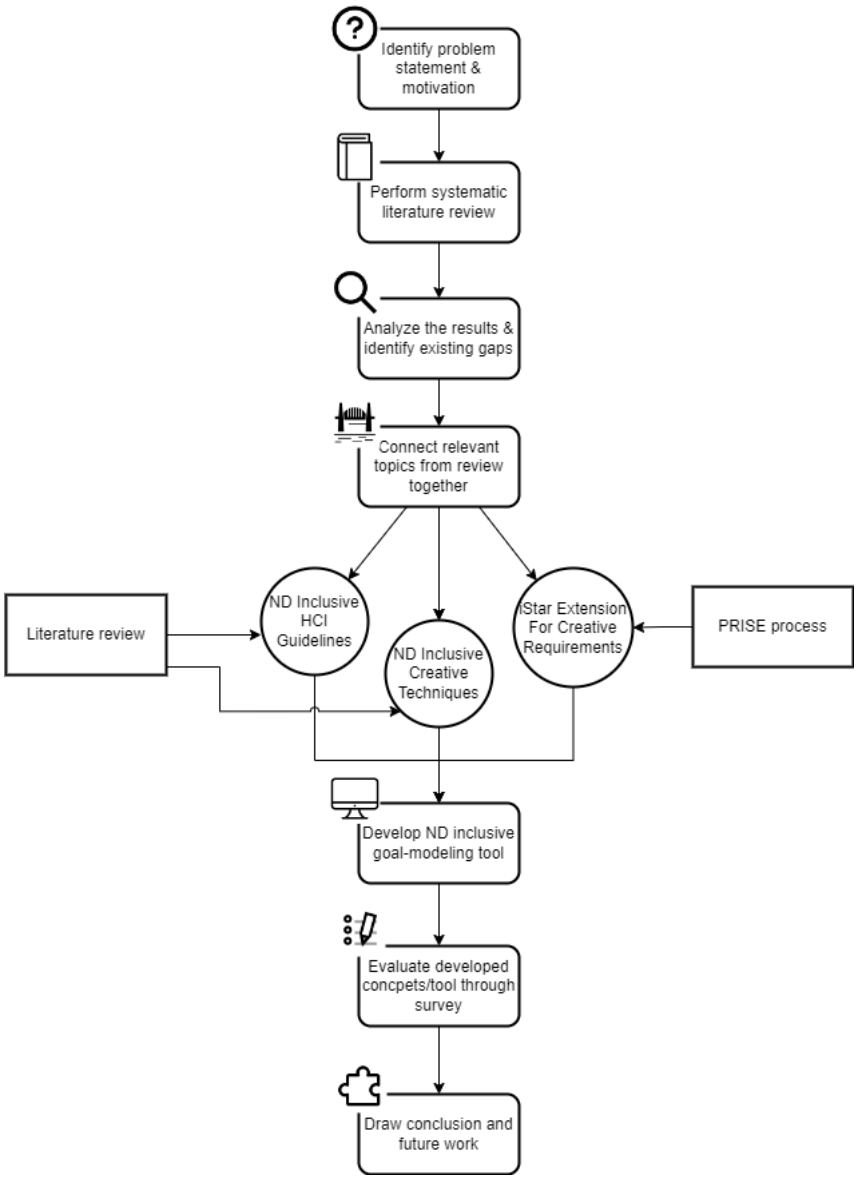


Figure 1.1: Overview of the methodology used

1.4 Methodology

To achieve our goal, we started with a systematic review to understand what the issues are that neurodivergent software engineers face and how software applications can be more accessible to individuals with those characteristics, which can be found in Chapter 3.

The systematic review showed that there is a lack of existing solutions or methodologies to bring accessibility to neurodivergent software engineers, demonstrating a big gap in this topic. Since there wasn't any work directly tackling the topic of this dissertation, we had to connect some previously explored areas that haven't been explicitly linked before to our knowledge. For example, we found that a common connection between all neurodivergent conditions is the capability to be creative and bring innovation to

IT companies. We also found out that creativity in requirements engineering has been explored before, showing the positive benefits of implementing creativity techniques in that setting. So, by taking and connecting this information, it led us to choose to work on the requirements engineering phase of software development and bring a solution that uses creative techniques, which will shed light on the creative side commonly found in neuro-atypical individuals. To achieve this, we decided to develop a goal-modeling tool based on the iStar language that includes creative concepts and methods to develop models.

The systematic review showed that neurodivergent users struggle with using websites that don't feature inclusive interfaces in their design. To address this issue, we developed a set of neurodivergent-inclusive HCI guidelines. We also gathered many creative techniques together to implement in our tool. Then, we extended the iStar language to be used alongside creative techniques.

We didn't have enough knowledge when it came to existing HCI guidelines and creative techniques, meaning we needed to expand the amount of related work we had from the initial systematic review by doing a literature review on those topics. We clustered the guidelines we found into different categories to form a table of neurodivergent-inclusive HCI guidelines. In the case of the creative techniques, after gathering them we classified them in terms of their accessibility to individuals with neurodivergent conditions.

To bridge the use of creative techniques with the iStar language, it was clear to us that there was a necessity for our iStar extension to have new elements that would support a more creative setting while also reducing some abstraction in terms of the relation of the generated ideas and the existing elements on a model. To make sure we used the best practices to develop the extension, we used the PRISE [29] process.

The conceptualization of the three main concepts for our approach (HCI guidelines, creative techniques, and the iStar extension) are presented in Chapter 4.

Finally, we take all of the concepts that we defined until this point and develop a prototype of the previously mentioned goal-modeling tool. We use the open-source iStar modeling tool *piStar* as a base of our prototype and add the features that make it become our neurodivergent-inclusive software engineering approach.

We also evaluated the concepts of the approach as well as the resulting prototype through *Google Forms* to understand how beneficial the approach and tool are to neurodivergent individuals and goal-modeling experts. The results were promising, as our neurodivergent participants found use in the accessibility approach and our goal modeling experts understood and supported the creativity methods applied to iStar. Some alterations and additions were suggested to refine and complete the approach.

1.5 Contributions

Through this dissertation, we expect to contribute to the requirements engineering field with the following:

- A systematic literature study on how neurodiversity has been addressed in the context of software engineering
- An analysis of neurodiversity-related issues for software engineers in their workplace and the use of applications with neurodivergent accessibility in mind;
- An analysis and comparison of existing tools, techniques, and methodologies for accessible software applications for neurodivergent individuals;
- A set of neurodivergent-inclusive guidelines for requirements elicitation and analysis;
- A gathering of neurodivergent-inclusive HCI guidelines and creativity techniques;
- An iStar extension to support creative requirements;
- An evaluation of the concepts defined for the neurodivergent-inclusive approach, as well as the developed tool;
- A neurodivergent-inclusive supporting approach and tool for the requirements engineering process.

1.6 Document structure

This document includes seven chapters and is structured as follows:

- Chapter 1, *Introduction*, introduces the context and motivations for this thesis, identifies the problem statement and the associated challenges, and presents the objectives and expected contributions.
- Chapter 2, *Background*, provides a brief description of the concepts this thesis preparation is based on.
- Chapter 3, *State of the art*, presents the conducted systematic literature review and a discussion of its results and provides an overview of the current state of the art on neurodiversity accessibility issues in software engineering.
- Chapter 4, *Conceptualization of the neurodivergent-Inclusive Goal Modeling tool*, shows the different concepts that were defined to build the tool that encapsulates all of the aforementioned concepts.
- Chapter 5, *IdeaStar - A Neurodivergent-Inclusive Goal Modeling Tool*, describes the main features in-depth of the resulting prototype of the proposed tool, as well as examples of using the tool to add new elements to an existing model.

- Chapter 6, *Evaluation*, reports the evaluation of the concepts defined in Chapter 4 as well as of the developed tool described in Chapter 5, including the planning and the report of the results of the questionnaire.
- Chapter 7, *Conclusions*, concludes the dissertation and presents opportunities and contributions for future work.

2

Background

The proposed thesis aims to address neurodiversity issues in the requirements engineering phase of software development. In this chapter, we will briefly introduce the main concepts surrounding the field of requirements engineering and neurodiversity, which will serve as the basis for the thesis.

2.1 Requirements engineering

2.1.1 Requirements and its types

A requirement is described by Sommerville [82] as "*the descriptions of the services that a system should provide and the constraints on its operation*". Sommerville also considers that it can be divided into two different types:

- **User requirements** which are usually more broad statements written in natural language, along with diagrams, of the expected services that the system should provide.
- **System requirements** which are more formal and detailed descriptions of the systems' functions and constraints.

Requirements are also classified into two important distinctions:

- **Functional requirements**, which are about what the system should do in terms of features and functions.
- **Non-functional requirements**, which are not about what the specific services the system should have, but rather its general properties.

2.1.2 Requirements engineering process

Requirements engineering (RE) is the process "*by which the requirements for software products are gathered, analyzed, documented, and managed throughout the SE lifecycle*" [9]. It is a crucial phase of software development that can detect errors at an early stage that can be costly

in the future of the project if they remain undetected until later [17]. It is concerned with finding out who are the stakeholders of the developing software (these range from users, paying clients, and developers) and what their needs are which will be documented and subsequently implemented further on in order to meet their expectations [63]. The five key activities regarding requirements engineering are as follows [69, 82]:

- **Requirements elicitation task** is the starting point of the RE process to find the needs and constraints of the system that it is being developed. It is very important during this phase to understand the relevant sources of knowledge relative to the problem (system) at hand, as it might be distributed among many sources, such as stakeholders, laws, standards, etc. The goal of this task is to make all types of knowledge of the system clear to every stakeholder involved in the process.

- **Requirement negotiation task** is where an agreement of the various requirements gathered in the elicitation task is established among the stakeholders involved in the process. For this task, conflicts must be made explicit and for each conflict, the alternatives and underlying rationale are made clear.

- **Requirements specification/documentation** is the moment in RE where the elicited user and system requirements are written in a document called software requirements specification. It is usually written in natural language accompanied by tables and diagrams as well as forms, and graphical or mathematical models (in the case of system requirements, these should be avoided for user requirements), which should strive to be as clear and unambiguous as possible to stakeholders.

- **Requirements validation task**, is the process of checking whenever the requirements are aligned with the stakeholders' expectations and if there are no conflicts within the requirements themselves.

- **Requirements management** is the final task related to RE. Given that a system is constantly changing during its development, or that stakeholders get different perspectives of the problem as the development goes on, or that after the system has been released errors and omissions from the original requirements may arise, the requirements document should follow these changes as well by keeping it updated and consistent with the evolution of the system.

For our dissertation, after conducting a systematic review, we decided to focus on the requirements elicitation and requirements specification phases of requirements engineering.

2.1.3 Requirements engineering approaches

The different approaches and techniques found in requirements engineering are ways to analyze and document the requirements of a system. Although natural language

is normally used at the beginning of the requirements engineering process due to its expressiveness, it can also bring imprecisions or ambiguities [82]. Hence, visual models have been developed to include more precise and formal techniques to complement textual representations [37] such as the following (the information in these bullet points are from [14]):

- **Structural modeling** is a semi-formal approach, as its main concepts are formal, by trying to define the connections and relations of the problem world, but the specification of such concepts uses natural language. Examples of techniques in this category are **Problem Frames** and **Class Diagrams**.
- **Behavioural modeling** is a type of approach that focuses on the relations between the existing agents of the system. Examples of techniques in this category are **Scenarios** or **State Machines**. It can also include agile modeling/specification techniques as well.
- **Goal modeling** is an approach that centers on the needs of actors or system components and who or what can achieve those goals. Examples of techniques in this category are **KAOS** and **i***.

2.1.4 The iStar (i*) language

iStar, formerly known as i*, is a goal- and actor-oriented modeling language that focuses on "*the intentional (why?), social (who?), and strategic (how? how else?) dimensions* " [18]. It has the benefit of being an open language that facilitates the creation of extensions to fit the necessities of engineers and businesses [35]. At the time of writing this dissertation, iStar is in version 2.0 which standardized the main concepts in an effort to make it more accessible outside of the experts community [18].

The main basis of this language lies in the interactions between actors which establish dependencies between each other, where one desires something that the other can offer and/or help achieve, as shown in Figure 2.1.

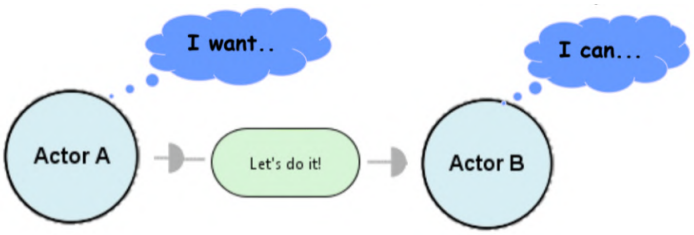


Figure 2.1: The core of relationships in i*, a dependency between two actors [19] (the cloud bubbles on each actor are not part of the i* language)

In Figure 2.1, Actor A is what is called a *depender* and Actor B is a *dependee*. The element within the dependency is an *Intentional Element*. An *Intentional Element* can be a *Goal*, a *Quality*, a *Task*, or a *Resource*.

An *Actor*, being an active and autonomous entity in the model, can be of type *Role* or *Agent*. If the distinction is not important, then the notion of a generic *Actor* can be used. These types of *Actors* are interrelated with a generic *Actor* through an *Actors Association Link*, which can be of type *is-a* or *participates-in*. The actor's boundary, a graphical container for the intentional elements of actors and their relationships, makes actors' intentions visible.

A i* model is filled with various dependency links between *Actors* and *Intentional Elements*.

The existing types of Intentional elements are the following:

- *Goal*, A scenario that the actor aspires to have and that has specific criteria for success;
- *Quality*, a quality that an actor aspires to have to some degree. The degree of achievement might be specified in detail or left unclear;
- *Task*, describes the desired actions of an actor, usually with the intention of reaching a certain goal;
- *Resource*, an object or provider of data that the actor needs in order to complete a task.

A model can be viewed in three ways:

- As a *Strategic Dependency (SD)*, which demonstrates each actor in the model, their association links, and the dependencies between depended and dependee. Figure 2.1 is an example of this type of view.
- As a *Strategic Rationale (SR)*, shows all of the detail captured in the model, including actors, dependencies, actor association links, and the internal details of each actor. An example of this type of view can be seen in Figure 2.2 [19].
- As a *Hybrid SR/SD*, which combines both SR and SD views with some actors open and others not, giving focus to some actors. Figure 2.3 shows an example of such type of model where the focus is placed on the student actor with the other actor's boundaries closed off.

The four types of links between Intentional Elements are summarized in Table 2.1. These links are always seen within an actor's boundary. The link types between intentional elements are the following [18]:

- *Refinement*, which is "an n-ary relationship relating one parent to one or more children. An intentional element can be the parent in at most one refinement relationship." Can be of type *AND* (all *n* children must be fulfilled to satisfy the parent) or *Inclusive OR* (at least one child must be fulfilled to satisfy the parent);

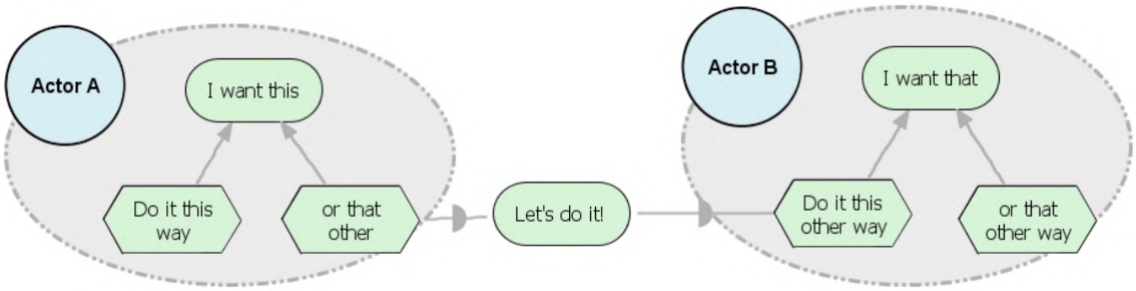


Figure 2.2: An example of a i* model in a SR view [19]

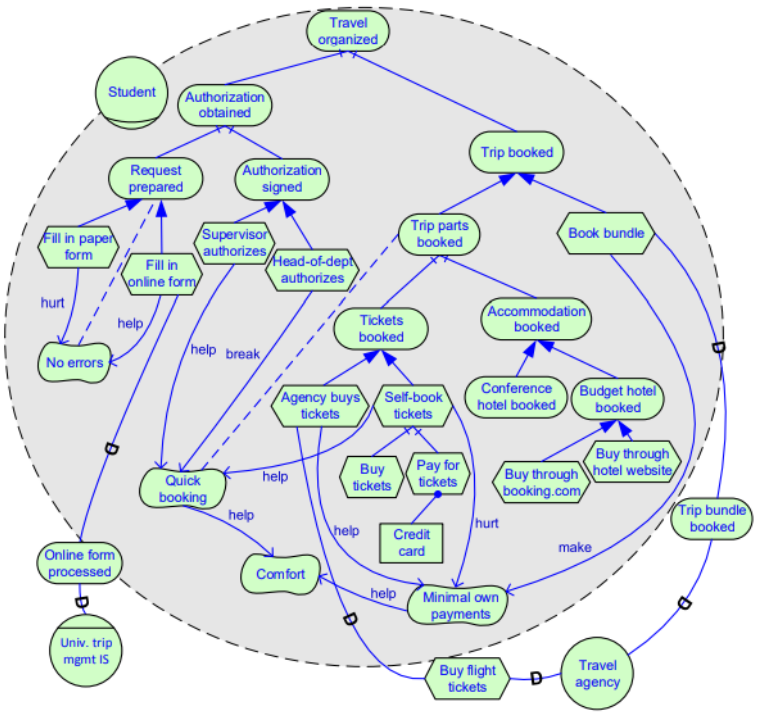


Figure 2.3: An example of a i* model in a Hybrid SR/SD view[18]

- *NeededBy*, which "links a task with a resource and it indicates that the actor needs the resource in order to execute the task";

- *Contribution links*, which "represent the effects of intentional elements on qualities". Can be of type *Make* (very positive effect), *Help* (positive effect), *Hurt* (negative effect), *Break* (very negative effect).

- *Qualification*, which "relates a quality to its subject: a task, goal, or resource" and "expresses a desired quality over the execution of a task, the achievement of the goal, or the provision of the resource".

		Arrowhead pointing to			
		Goal	Quality	Task	Resource
Link starts from	Goal	Refinement	Contribution	Refinement	n/a
	Quality	Qualification	Contribution	Qualification	Qualification
	Task	Refinement	Contribution	Refinement	n/a
	Resource	n/a	Contribution	NeededBy	n/a

Table 2.1: Overview of link types between intentional elements[18]

2.1.5 Creativity approaches in requirements elicitation

Agile approaches have long been used in software engineering as a way to deal with the emerging complexity of software development, as stated by Aldave [2]. She also points out that these approaches "*tend to focus solely on scoping and simplicity rather than on problem-solving and discovery*". In her systematic review, she shows a decade's worth of research on how inserting creativity in the requirements elicitation process can be beneficial to bring innovative ideas to software in an ever more competitive industry that can tackle problems directly and resolve them.

Creativity is considered to be a complex concept to define due to its ambiguity, meaning that there isn't one accepted general definition [4]. However, within the various definitions for creativity, researchers agree that it's the production of something that's both novel and that it holds value as ideas of their own or to resolve problems [1].

Various creativity techniques have been proposed for different purposes. Franco [26] has gathered 30 different techniques from many different papers in his literature review. He divides into two separate categories with the following techniques:

- **Representation-oriented**, which covers the ways that requirements are represented. It includes Topic Maps, Goal Modeling, Scenarios, and Storyboards.
- **Process-oriented**, which is divided into three subcategories:
  - **Organizational perspective**, it is concerned with the way the elicitation process is organized. It includes *Creativity Workshops*, *Brainstorming*, *Roles playing*, *Walt Disney*, *Game mechanics*, *Positive space design*, *Hall of fame* and *Creative spaces for conversations*.
  - **Cognitive perspective**, considers the cognitive ability associated with creativity. It includes *Constructivist learning*, *Analogies*, *Presenting solution space knowledge*, *Constraints removal*, *Combining ideas*, *Walkthroughs*, *Viewpoints*, *Deconstruction*, *Questions list*, *Heuristics*, *Why why why?*, *Idea box*, *Design rationale*, *Physualization*, *Speed modeling*, *Picture stimulation* and *Cultural probing*.
  - **Psychological perspective**, where creativity is encouraged by stimulating the individuals' state of mind. Only one technique in this subcategory has been found in the research, that being *Influence positive emotions*.

2.2 Neurodiversity

2.2.1 Important definitions

Neurodiversity, a term coined by Judy Singer [80], refers to the diversity of the human brain in the form of various conditions that diverge from the typical cognitive style of thinking expected from society, moving away from the perspective of seeing such conditions as problematic, but instead as another form of human differences like race or gender [7]. Some of the common conditions associated with neurodiversity are the following [5]:

- **Austism Spectrum Disorder (ASD)**, categorized by a struggle in social interactions, narrow interests, repetitive behavior, and lack of non-verbal communication [78]. Historically, Asperger was once considered a separate diagnostic from classical autism [95]. The distinction came from those who had what was considered a milder form of autism (i.e., less severe symptoms and better language and cognitive skills) [8]. Later, on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders, this distinction dropped in favor of fitting autism as a spectrum [30].

- **Attention Deficit Hyperactivity Disorder (ADHD)**, marked by constant inattention, hyperactivity, and impulsivity [87]. Very often, symptoms of this condition are noticed in children of age under 12 years old, since it is when they change their surroundings to places that expect more attention from them, like schools for example, as stated by the UK's National Health Service [64]. NHS also states that a significant part of the cause for developing ADHD is through genetics inherited from their parents whose family has had cases of ADHD.

- **Dyslexia**, a disorder identified primarily by a learning difficulty in reading and spelling fluently. Although it is usually found in children it can become a lifelong condition [50]. Despite being considered a neurodivergent condition, dyslexia does not affect the intelligence of its individual [22]. There are three major levels where dyslexia affects the individual's brain, those being "*behavioural (difficulty with reading and writing), cognitive (information-processing mechanisms) and biological (neuro-anatomical and genetic)*" [90].

2.2.2 Struggles

Even though neurodiversity brings an important perspective to see the diverse human brain conditions in a different and more accepting light, we should also keep in mind their associated struggles. Some examples of such struggles associated with each condition are:

- People diagnosed with autism, due to their lack of social and communication skills and a general stigma from society, often find themselves either unemployed or under-employed [46]. Another regular struggle found within the autistic community is their

low participation in education beyond high school, especially those in " *lower-income families and those with greater functional impairments*" [79].

- Those diagnosed with ADHD struggle with school in general due to their inattentive and impulsive behavior, which makes it harder for them to be as consistent and effective as necessary for a school environment [48]. The previously cited paper also points to how they experience loneliness and rejection due to society's low tolerance for the condition and their own difficulty in social interactions. As adults, those with higher ADHD symptoms may lead to lifestyles with poor diets and substance abuse [94].

- As for individuals with Dyslexia, any activity that involves either writing, reading identifying speech sounds, or decoding letters and words is a struggle for them, which is recurrent in school, especially the early years [23]. Their learning difficulties, in conjunction with failures in school, can lead to the development of self-esteem issues that can leave traumas into their adulthood [54].

2.2.3 Strengths

Despite the regular everyday struggles that neurodivergents have in the face of a neurotypical society, each condition also has its own strengths [6]. Returning to Armstrong's [5] research on neurodiversity, he states the following characteristics as strengths found in various conditions (some of these can be context-dependent and might not necessarily be found in all neurodivergent individuals):

- Autistics can be strong systemizers and follow routines to a tee, have a prodigious memory, have visual-spatial skills, and exceptional talents in very specific areas.

- Individuals with ADHD can be spontaneous, have high energy, are divergent or innovative thinkers, are risk-takers, and have attention to detail or high precision.

- Dyslexics, like those with ADHD, can also be divergent or innovative thinkers, or, like those with ASD, can have visual-spatial skills. But they also have the unique skill to have the ability to see the "big picture".

- Characteristics that are common within all of the conditions mentioned above are a high focus (related to interests) and creativity (in specific areas).

2.3 Summary

In this chapter, we introduced the two main topics of which our dissertation will be about, requirements engineering and neurodiversity. On the topic of requirements engineering, we defined what is a requirement and what types there are, the different phases of the requirements engineering process, and the available approaches to tackle them, including a

section focused on introducing the iStar language and a section about creativity approaches specifically.

As for neurodiversity, we clarified what the term refers to, some of the conditions associated with it, that will be the focus of our work, and their characteristic struggles and strengths. Now that we laid out the background necessary to understand the context of our thesis, we will proceed to the next chapter where we will understand the current state of the art for approaches that have been developed until now.

3

State of the Art

3.1 Research methodology

As we have stated before, with this thesis we want to focus on neurodivergent accessibility in software engineering tasks. In order to obtain the research that has been done about this topic so far, we performed a **systematic literature review**. This process will be performed in three stages:

- *Planning stage*, where we will define our research questions, search strategy, study selection, and data extraction strategy;
- *Conducting stage*, where we will go through the steps laid out in the previous section and obtain the studies and desired information;
- *Discussion of the results*, where we will synthesize the information obtained into different categories from each of the research questions.

Please note that all of the techniques shown in the next sections are based on the guidelines set by Keele [42].

3.1.1 Planning stage

This is the first stage of a systematic literature review and will be conducted in the phases described in section 3.1. The aim of the following sections is to detail each of those phases.

Research questions

To get an overview of what has been developed in the last few years when it comes to neurodiversity-friendly approaches in software engineering, we constructed our research question using the **PICOC** method. This method provides five elements to frame research questions and it is described in table 3.1.

This leads to the definition of our main research question:

How has neurodiversity been addressed in software engineering?

Population	Studies that cover neurodiversity in the context of software Engineering
Intervention	The set of methods, tools, and techniques that address inclusivity measures in software engineering
Comparison	The proposed approaches are not compared with each other.
Outcomes	Gather different approaches in order to make Software Engineering tasks more accessible to neurodivergent engineers, in the form of a neurodivergent-inclusive tool for such purpose
Context	Academic, small scale

Table 3.1: PICOC analysis table

Since this is a very general question, in order to have a more focused search for our topic at hand, we decided to decompose the main research question into four sub-questions as shown in table 3.2. Notice how there are two distinct categories present within these questions, on one side we are concerned with knowing more about the experiences of software engineers who are neurodivergent (RQ1 and RQ2), and on the other, we look at the approaches that have been explored to make software applications more accessible to neurodivergent individuals (RQ3). These two categories will allow us to find the existing gaps when it comes to inclusivity for neurodivergents in software engineering.

Research sub-question	**Motivation**
RQ1. How are neurodivergent software engineers affected by their condition in their job?	To discover the differences between a software engineer who is neurotypical and someone who is neurodivergent
RQ2. What approaches have been proposed to accommodate the lives of neurodivergent software engineers?	To discover what methods, guidelines, and techniques have emerged to make software engineering more inclusive to neurodivergent individuals
RQ3. What approaches have been proposed to make software more accessible to neurodivergent individuals?	To discover what tools, techniques, and methods exist to address inclusivity and accessibility in software applications
RQ4. How effective were the neurodivergent inclusive approaches compared to the traditional ways?	To understand whether the approaches developed in RQ2 and RQ3 have been tested and approved by experts and the neurodiversity community

Table 3.2: Research sub-questions

Search strategy

The search strategy was conducted using an automatic method, where we used a database search with a search string containing the different keywords relevant to the research questions proposed in table 3.2, connected by the logic operators *AND* and *OR*. The

following string was the one applied for our search strategy:

"Software Engineering" AND ("Neurodiversity" OR "neurodivergent" OR "Autism" OR "Autistic" OR "ADHD" OR "Dyslexia" OR "Dyslexic" OR "Asperger")

The search string was run as a query on two separate digital libraries, IEEEXplore and ACM Digital Library, which are part of IEEE and ACM respectively, two of the most relevant publishers in the Engineering and Computer Science research community.

Study selection strategy

After running the search string on the IEEE and ACM, we proceeded to the selection of the studies themselves, where we evaluated the results based on our own inclusion and exclusion criteria so that we could be sure that the papers selected were relevant to answer our research questions. This evaluation was performed in two iterations. Firstly, we analyzed and read the title and the abstract of each study, selected the studies that met all of the inclusion criteria, and excluded the studies that met at least one of the exclusion criteria.

In the second iteration, the pre-selected candidates from the first iteration were read in full, and only those that satisfied all of the inclusion criteria were selected as final primary studies. The inclusion and exclusion criteria for the first iteration can be found in table 3.3 and for the second iteration in table 3.4.

ID	Study inclusion criteria
IC1.1	The paper is in English
IC1.2	The paper is from a conference or a journal
IC1.3	The paper is available in full text
IC1.4	The title and/or the abstract of the paper is related to any of the research questions
	Study exclusion criteria
EC1.1	The paper is not in English
EC1.2	The title and/or abstract of the paper is not related to the research questions

Table 3.3: Inclusion and exclusion criteria for the first iteration

Data collection and extraction

In order to collect information from the papers that would answer our research questions in a concise and focused manner, we created a data extraction form template for that purpose. This way we can keep all of the information in one place, while also ensuring that each paper is subject to the same extraction criteria. The form was based on the sub-research questions while also covering some additional details for extra context, like what kind of app was developed and who it was aimed for (if it applies to the paper in question), how many neurodivergent individuals participated and how the tests/interviews were conducted. The form can be viewed in table 3.5

ID	Study inclusion criteria
IC2.1	The content of the paper discusses any of the research questions
	Study exclusion criteria
EC2.1	The content of the paper is not focused on any of the research questions
EC2.2	The paper discusses challenges related to the main research questions but does not state any solutions
EC2.3	The paper is a duplicate
EC2.4	The paper is a secondary study

Table 3.4: Inclusion and exclusion criteria for the second iteration

Paper Identification
Paper Title ID
Neurodivergent Software Engineering Experience
How are neurodivergent SE affected by their condition in their job? What efforts are being made or should be to accommodate their lives as SE?
Accessible Software
When making directed/accessible software to neurodivergent individuals, which measures/approaches (Eg.: tools, techniques, models, processes,...) should be or are being taken into consideration? What's the targeted age of the software being made? What kind of software is it? What's its purpose?
General Information
How effective were those changes compared to the traditional ways? How many neurodivergent individuals participated in the study? What was their condition(s)? How were interviews/experiences/tests conducted?

Table 3.5: Data extraction form

3.1.2 Conducting stage

After finalizing the details for the planning stage, as described in section 3.1.1, we proceeded with the plan. As we mentioned, we ran the search string through the IEEE and ACM libraries. For IEEE, when we ran the string it returned 2,682 results, but we applied a "*Software engineering*" publications topics filter available on the site itself, and it returned 14 results, where we analyzed every single one. As for ACM, we initially got 252 papers in total and then applied a search within full-text filter, of which we got 224 papers. From those ACM papers, we analyzed 64 of them. We read through the titles and abstracts of each paper and applied the first iteration criteria (shown in table 3.3), where we excluded 8 papers from IEEE and 35 from ACM. The papers that were selected from the first iteration were then fully read and were where we applied the second iteration criteria (shown in

table 3.4), where we excluded 13 papers from ACM. In the end, we selected 22 papers. The summary of the results obtained from following the process described above is shown in table 3.6.

	1^{st} Iteration Studies
Exclusion Criteria	78
EC1.1	-6
EC1.2	-37
Total	35
	2^{nd} Iteration Studies
EC2.1	-7
EC2.2	-4
EC2.3	-1
EC2.4	-1
Final Total	22

Table 3.6: Results of the conducting stage

3.1.3 Discussion of the results

In this section, we will show and discuss the results of the planning and conducting stages (detailed in sections 3.1.1 and 3.1.2 respectively). We will return to each sub-research question and answer them based on the analysis of the information extracted from the selected studies.

RQ1. How are neurodivergent software engineers affected by their condition in their job?

When it comes to the experience of software engineers that have a neurodivergent condition, from the 8 papers that focus on this topic, 5 of them were in the context of the workspace [60, 40, 45, 70, 3] and three in education [85, 61, 13]. They focused mostly on autistic individuals with some briefly referring to other conditions like ADHD or Dyslexia. The main points taken from the papers revolve around the importance of social skills within a team setting, where **communication and social skills** are required, something that is fundamental to Software Engineering, and that it is a challenge to autistic individuals since their lack of such skills is a lot of times part of their condition [60, 61, 13]. **Software distractions** are also another relevant issue that is discussed, be it for notifications [60] or secondary content like animations in applications [3]. Finally, the other common problem related to neurodiversity in the context of Software Engineering is when it comes to **tasks that involve more abstract concepts** and are not as procedural [60, 85]. The reason for this issue is explained in Stuurrman's article [85], where he describes the "weak central coherence" cognitive style present in autistic individuals, meaning that they can more easily focus on the details whereas they struggle to get the essence of some concept.

RQ2. What approaches have been proposed to accommodate the lives of neurodivergent software engineers?
In order to make the lives of neurodivergent software engineers more comfortable and appropriate to the effects of their conditions, some papers discussed measures that can help them such as **being able to be open about their conditions and educate other employees on neurodiversity** [60, 85], possibly by using methods like **sociodrama** [45] or **hypnotisis** [40] and **having explicit rules and steps laid out for any task** whenever it is possible [85, 61]. In general, these papers trace to the importance of having neurotypicals be more considerate of their neurodivergent peers, making them more comfortable and included in their jobs.

RQ3. What approaches have been proposed to make software more accessible to neurodivergent individuals?
The most researched measure to make accessible software to neurodivergent individuals is to make **adaptive interfaces** [83, 55, 25, 53] since most disorders fall into a spectrum where different users have unique needs for themselves. Another common suggestion is to **decompose tasks step by step** and **avoid sudden changes** [56, 31, 58]. For mobile applications with autistic individuals in mind, one paper suggested the use of **grid list, carrousel, and Wizard patterns** in their UI design [56] and another pointed that **the UI should be as responsive as possible** [58]. Some papers focused on general techniques for developers to make sure their software is more accessible to neurdivergents at the requirements elicitation phase, either using the accessibility guide called GAIA to **transform User Stories into UserX Stories** [67] or two artifacts that consist of **interview scripts and canvas** [57]. Participatory design is also widely suggested [88, 28, 15], be it with neurodivergent individuals by **using a design framework called Diversity For Design (D4D)** [15], **interviews with experts and focus group sessions** [88] or **using agile methods** along with it[28, 59].

Since a lot of the papers that had some form of software being developed were done for education or treatment purposes, most of them were targeted at children [83, 56, 25, 67, 58, 53, 59, 15]. Some could be considered to be fit for any age gap [55, 88, 28] and one was more specifically targeted to adults [31].

The two most unique applications described in the selected papers were an assistive task queue to give appropriate tasks to autistic workers in crowd work [31], a daily routine activities register and tracker [67], and a mobile app to motivate autistic users to exercise [88]. These three papers could be referred to as "productivity boost" applications.

RQ4. How effective were the neurodivergent inclusive approaches compared to the traditional ways?
Unfortunately, most papers did not evaluate their measures/techniques, as in controlled experiments or self-rating from neurodivergents, and left applying them as future work [60, 85, 55, 76, 53, 59, 15]. Those that did have trials with neurodivergent individuals

reported to have success with their strategies to achieve more accessible software with their own projects [83, 56, 3, 31, 59]. Another measure of success was related to improving communication and team skills with autistic individuals [61, 45, 40, 13, 88]. Finally, techniques that were aimed at helping developers familiarize themselves with neurodivergent conditions and what considerations to take to make their software accessible to them also showed positive results [25, 67, 57].

3.2 Synthesis of the results

Gathering all of the information we could get from the selected papers shows that there is interest in finding and developing approaches to accessibility and inclusivity in software applications relating to neurodiversity, even if it is still a recent research topic as a lot of the papers found were from 2020 onward. We reviewed the existing literature to understand how neurodivergent software engineers are affected by their condition and what approaches have been proposed to address those issues as well as in the making of accessible software.

As discussed in the previous sections, it is clear that neurodivergent people have unique conditions that affect how they work and how they use any kind of software application. Looking at the extracted information from the papers at large, a lot of progress in developing applications that help with their struggles from their conditions and in the education of neurodivergent children have already been made.

On the other hand, those papers focused on a neurodivergent children's point of view, with very few focusing on issues that working neurodivergent adults face at their job, much less on those who are software engineers. It is certainly important to find solutions to help neurodivergents' needs from an early age, but neurodivergent adults deserve focus as well since they have their own obstacles when trying to fit themselves into society's standards.

When it came to neurodivergent software engineers and how to accommodate their needs and appropriate their special skills for tasks such as requirements engineering or modeling, we could not find any research done on that specific topic. Still, the papers that we selected and analyzed served as important groundwork to form our proposed solution in our dissertation.

Table 3.7 summarizes the most relevant data found, i.e. the most prominent topics discussed in all of the selected papers, in our systematic literature review. It's divided by a description of a neurodivergent related issues, the affected condition(s), what technique/approach should be applied to solve it, and where it can be applied according to the authors of said papers.

Issue	Affected Condition(s)	Technique/Approach	Applicability
Difficulty in communication [60, 61, 13]	ASD, Dyslexia	Give preference to digital correspondence to autistics and verbal communication to Dylexics.	Workplace
Lack of social skills [60, 61, 13]	ASD	Let neurodivergent individuals be open about their condition. Educate employees on neurodivergent conditions.	Workplace
Software distractions [60, 3]	ADHD, ASD	Eliminate notifications that aren't about the main task and reduce animations in tools.	Software
Tasks with abstract concepts [60, 85]	ASD	Have tasks with explicit rules and laid out steps.	Workplace, Software
User interface not catered to neurodivergent individuals [83, 55, 25, 53, 56] [31, 58, 88, 28, 15]	ASD, ADHD, Dyslexia	Build adaptive interfaces. Let neurodivergent individuals participate in the design process	Software

Table 3.7: Synthesis of the main data extracted from the systematic literature review

3.3 Threats to validity

Throughout the design phase of the systematic literature review for this investigation, we made steps to reduce risks and subsequently improve the accuracy and completeness of the findings. But just like all studies, the ones that were used had drawbacks and implications that put the reliability of the conclusions at risk. We followed the guidelines set by Wohlin [96] to identify these threats in the context of investigations in software engineering.

Internal validity

There is always a chance that not all pertinent studies will be included in a systematic literature review. Although we made an effort to collect all the keywords' synonyms that correspond to the research questions when establishing the search string utilized in the automatic search, the results may still be incomplete because there may be pertinent studies that do not include the searched keywords. This is especially true in our case since we started with a much broader research question that we were only able to specify after the systematic review. Because only one person was responsible for study selection and data collecting, and the number of studies was large, a data extraction form and a set of inclusion and exclusion criteria were developed to avoid, at least to some extent, injecting selection bias into the process.

External validity
Although we initially looked through *Google Scholar* to give us a broad range of results from various conferences, journals, and organizations, we later focused on just two organizations, IEEE and ACM, which could mean we missed important papers from other different sources. However, some of the initial smaller batch of papers that we selected through *Google Scholar* on our initial search were also found later when searching IEEE Explorer and ACM Digital Library.

Conclusion validity
Since we don't know how the search engines of the used digital libraries work, we made sure to avoid refreshing the search results when looking through the available papers to make sure the results didn't differ on the same digital libraries. For each chosen study, we also developed a data extraction form to structure the information needed to respond to each research question.

3.4 Related work

The present thesis started with the problem of how neurodivergent individuals struggle with software engineering tasks when compared to their neurotypical peers. In order to have a better understanding of what are the existing approaches to tackle neurodiversity in software engineering as a whole, we proceeded to do a systematic review. Although initially we wanted to gather information related to neurodiversity and software engineering tasks such as requirements elicitation and modeling, it quickly became clear that there was a big gap within that specific context, so we shifted our focus to the neurodivergent engineer point of view and the tools and techniques that are being used to develop accessible software to neurodivergent individuals.

We did consider excluding papers that either focused on children, treatment of neurodivergent conditions, or education of neurodivergent individuals, but once again we were confronted with a lack of papers focused on neurodivergent adults. Still, the selected papers were important to show the base work that has been done so far in regard to this issue that will be used for our own solution.

In general, we found evidence that pointed to neurodivergent individuals with autistic conditions having particular skills that can be quite productive to companies since "*they favour innovation and organisational agility*", showing there is "*a strong complementarity between the cognitive skills of autistic workers, innovation and skills demanded in IT roles*" [91].

One paper, in particular, sparked our interest, which was Benton's *et al* article *Diversity for design: a framework for involving neurodivergent children in the technology design process* [15]. This paper introduced a participatory design (PD) framework, Diversity for Design (D4D), that in the authors' words, "*provides guidance for technology designers working with neurodivergent children in establishing PD methods that capitalize on children's strengths and also support potential difficulties*". Although the paper focuses on children for its PD framework,

it still serves one of the main principles of the neurodiversity movement of spotlighting the strengths unique to neurodivergent individuals. This paper based their approach on the research done by Armstrong on the topic of neurodiversity [5] and included a table that summarized the characteristic strengths and difficulties associated with neurodivergent conditions such as ASD, ADHD, or Dyslexia. The one common strength associated with all conditions as shown in the said table is creativity. This paper also cites the work done by Warr and O'Neill [92] which states that creativity in design can lead to more useful and usable software, which can be considered as one of the goals within requirements engineering, which is defined by Jin as "*to make the problem that is being stated clear and complete, and to ensure that the solution is correct, reasonable, and effective*" [41]. Hoogman [33] also studied the link between ADHD and creativity, stating "*positive trend of increased creative achievements among individuals diagnosed with ADHD*".

Creativity in requirements engineering is a topic that has been researched before [75, 44, 26]. Svensson and Maryam [86] studied the effectiveness of four different creativity techniques for requirements engineering where the Hall of Fame technique was revealed to be one of the most promising as it was the one with the most creative requirements that were included in the future releases. Concrete uses of creativity in requirements elicitation have been reported, like in the development of an air space management software system in the UK [52], where 76% of the ideas generated from a creativity workshop impacted the final specification of the system.

3.5 Summary

In this chapter, we showed what's the current state of the art relating to approaches for inclusivity of neurodiversity in software engineering through a systematic review. We showed the three phases of said process in detail, defining the research questions, the search string that was used on the digital libraries, the number of papers selected based on our defined inclusion and exclusion criteria, and a discussion of the results, where we ended up with a set of approaches/techniques to resolve neurodivergent issues to be applied in the workplace or in software. Towards the end of this chapter, in the section for related work, we start to understand what will be the main focus of our solution, which we will detail further in the following chapter.

4

Conceptualization of the neurodivergent-Inclusive Goal Modeling tool

With the main findings from the systematic review in mind, we will now proceed to describe the various stages and decisions that led up to the creation of IdeaStar, our neurodivergent-inclusive tool for iStar Goal Modeling. Firstly, we gather all the neurodivergent-inclusive HCI guidelines we can find to apply to our tool. Then we study what creativity techniques are the most ideal for NDI and what modifications they might need to fit them. Finally, we present an iStar extension to be used in our tool alongside the chosen creative techniques created using the PRISE process [29].

4.1 The Path To Our Solution

We began our thesis aiming at exploring ways to make software engineering tasks (e.g., requirements engineering, modeling, coding) more accessible to neurodivergent individuals. To understand this problem, we performed a systematic review from two main perspectives: the issues that neurodivergent software engineers face in their work, and accessibility in software applications for neurodivergent individuals. Although the selected studies did not respond to our main question directly, they still served as important information for the solution we envision to the described problem.

A primary study from the review about participatory design with neurodivergent individuals showed that creativity is found in every type of condition. Since creativity in requirements engineering is a topic that has been researched before (please see Section 3.4), we believe that there is potential for innovative solutions in this particular area of software engineering. So, for that reason, from now on in this dissertation, we will focus on the Requirements Engineering field for our solution.

4.2 Proposed Solution Outline

This section presents our **neurodivergent-inclusive requirements engineering approach**. Such an approach and tool are to be used by neurodivergent engineers with conditions like ASD, ADHD, and Dyslexia while taking it consideration their needs and special skills. The tool should let the user produce the same type of artifacts as they would with a non-neurodivergent-inclusive tool as well as all of the necessary features to do so. This way, the tool will reach a broader acceptance, as both neurodivergents and neurotypicals will not feel limited to do their job while using it.

Our solution covers two activities of requirements engineering: **Requirements Elicitation**, and **Requirements Analysis**. The Requirements Elicitation activity modifies existing creativity methods to create a neurodivergent-inclusive set of elicitation techniques. These techniques facilitate neurodivergent individuals to be more integrated participants in the elicitation process by considering their strengths as creative and hyper-focused individuals. The Requirements Analysis activity extends the iStar language to include concepts that facilitate the use of creativity techniques in requirements engineering. This extension will be realized using the systematic PRISE process [29].

By using the added concepts from the two previous requirements engineering activities, we will **develop a goal modeling web application called IdeaStar**, based on piStar [66], an open source goal modeling tool, that connects both ends in order to have a tool that guides its users through both activities. In other words, the web application will be divided into two sections, each representing the previously mentioned activities. The first part consists of eliciting and documenting requirements using neurodivergent inclusive creativity methods and then, in the second part, those same requirements are presented as *Idea nodes* for the user to model them to other elements, using our own iStar extension for the fact. Figure 4.1 shows a simplified outline of our solution.

With this type of linear flow and step-by-step approach to the initial phase of requirements engineering, we follow one of the main inclusive approaches already mentioned in table 3.7, that is, to have a more laid out set of rules for abstract tasks. Plus, the application interface and UI design **should follow the HCI neurodivergent accessibility guidelines** that we found based on our findings related to the topic.

The following sections in this chapter show the various concepts and definitions that were set to make our tool inclusive, which will cover three main topics: *Human Computer Interaction Guidelines*, *Creativity Techniques*, and *iStar extension*. Finally, the details of the resulting tool will be shown in chapter 5.

4.3 Neurodivergent-inclusive HCI Guidelines

Human Computer Interaction (HCI) has been defined as "*a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*" [81]. As the previously cited article mentions,

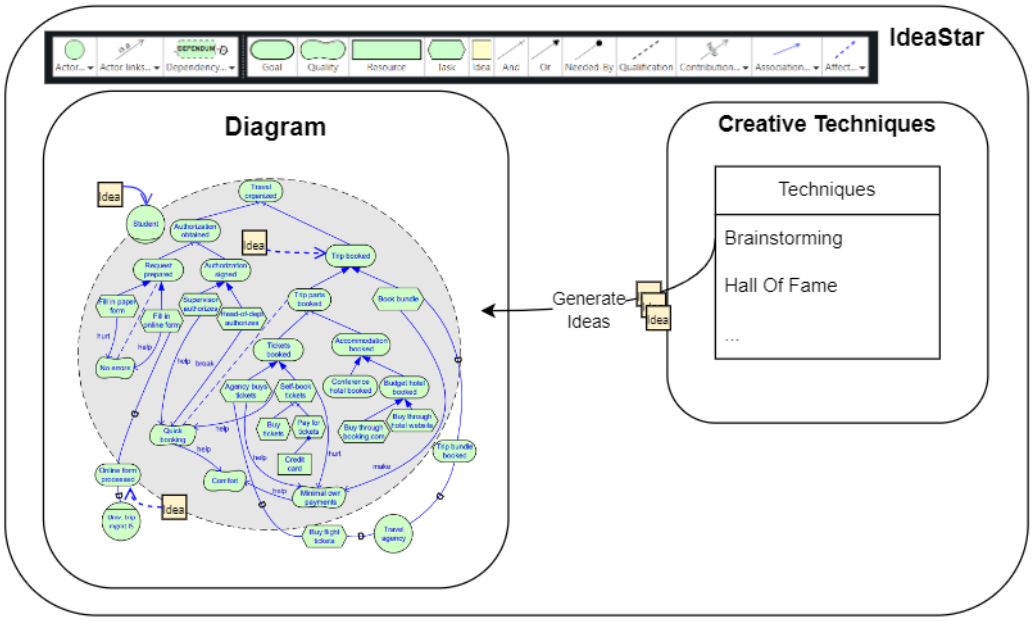


Figure 4.1: Diagram showing a outline of the proposed solution

through HCI software developers are able to find the best methodologies and processes to follow and create interfaces through which users can easily accomplish their tasks with as little effort as possible and so that computers can be prepared for their needs. As we have discussed before in this dissertation (mainly in sections 2.2 and 3.1.3), neurodivergent individuals (NDI) have their own way of thinking different from neurotypicals which will affect the way they interact with software. So, suppose we want to make sure that our tool is accessible to NDI. Before we go further into concepts more directly associated with the Software Engineering practice, we want to make sure that the interface of our tool is in line with the characteristics and needs of NDI. Non-confirming interfaces were one of the most found issues relating to neurodivergent accessibility that we found, as shown in the table of section 3.2. It is also worth noting that even beyond our target audience, making sure that we produce a user interface with accessibility in mind can benefit everyone [97], showing how relevant this issue is.

An article by Britto *et all* [16] (discussed in our systematic review) gathered 17 works with recommendations to design user interfaces for people with Autism Spectrum Disorder to produce a concise table of guidelines to follow. Since this article only reflects on Autism and we aim to be inclusive to individuals with ADHD and Dyslexia, given that our initial systematic review does not have any information regarding those topics, we did an extra literature review on it. We did a manual search on Google Scholar with the following keywords: *Neurodivergent* & *Autism* & *ADHD* & *Dyslexia* & *Web Accessibility* & *HCI Guidelines*. We selected articles/resources with any web accessibility guidelines for neurodivergent individuals. After applying said criteria we chose 8 extra resources to extract guidelines from [71, 65, 20, 76, 74, 73, 72, 27]. We then grouped the 80 guidelines

we gathered into 7 different categories as shown from table 4.1 to table 4.7. The sources for each guideline are found in the right-side column. While the purpose of gathering these guidelines was to help us in the creation of the tool, their applicability can go beyond Software Engineering tools and be used by anyone developing a website.

Table 4.1 presents the HCI guidelines related to the layout, visual and text presentation for the interface.

ID	Guideline	Source
1 - Layout, Visual and Text Presentation		
1.1	Use a simple, clear, and precise textual language, avoid jargons, spelling errors, metaphors, abbreviations, and acronyms, using terms, expressions, names and symbols familiar to users' context	[16, 20, 76] [72, 27]
1.2	Organize content into well-defined groups or chunks, using headings, titles, lists, and other visual-semantic organizing schemes, so that the information is succinct without resorting to long paragraphs	[16, 20, 76] [72, 27]
1.3	Use clear, sans-serif fonts like Arial, Comic Sans, Verdana, Tahoma, Century Gothic, Georgia, Helvetica, and Trebuchet. Limit text to only one font	[71, 65, 20] [76, 72, 27]
1.4	Use larger fonts, fonts in minimum 12pt or 14pt. However, larger font sizes should be used carefully so as to not clutter the page or difficult to read	[71, 20] [76, 27]
1.5	Limit or eliminate the use of italics or ALL CAPS. If the highlight is needed in headers, use text size and bold face for regular capitalized text	[76, 72, 27]
1.6	Don't right justify text, use ragged edge right hand margins instead	[76, 27]
1.7	Use ordered lists (or numbered lists) instead of unordered lists (or bullet lists)	[76, 27]
1.8	Use white spaces to ease reading. To improve comprehension of list items, use white space to separate marker from text and between items use double spacing	[76, 72, 27]
1.9	Assure that the website can be read by screen readers, thus guarantee that the markup is valid, provide alternative text, avoid unnecessary tables, and use semantic markup wherever use tables	[76, 72, 27]
1.10	Present text in a single column, while avoiding large amounts of text. Use fluid design so that the width of the columns can be adjusted to the browsers' window width or different zoom levels	[65, 76]
1.11	Use a simple layout design	[65, 76, 27]
1.12	Avoid textured backgrounds, moving images, decorative elements that do not convey information, and other visual or sonic "clutter" like pop-up elements. No element should stand out too much	[71, 65, 76] [72, 27]
1.13	Vertical scrolling should be minimized and horizontal scrolling should be strictly avoided	[71, 65] [20, 76]
1.14	Avoid moving text	[20, 76]
1.15	Use soft, mild colors like pastels for graphical elements, rather than sharply contrasting colors.	[65, 20, 72]
1.16	Highlight text as it's being read out loud (or allow users to activate this option), using boxes, borders, and background color to call user attention	[76, 72]

ID	Guideline	Source
1.17	The contrast between background, objects and text/fonts in foreground must be appropriate to distinguish items and distinct content or relate similar information	[16, 65, 20]
1.18	Prioritize information. Place the important parts of a paragraph (key points) in the first sentence	[76, 72]
1.19	Use the tag to explain abbreviations and acronyms	[76]
1.20	Avoid pure white as the background color. A close alternative is the light gray with the following hexadecimal code #FFFFE5	[76]
1.21	Do not use hyphenation of words that commonly are presented integrally	[76]
1.22	Use real text or vector-based text, rather than text within raster-based images, to allow for higher quality enlargement, without pixilation	[72]
1.23	Define terms that might have different meanings depending on social context, or that might be jargon related to a specialized field	[71]
1.24	Try to have one toolbar.	[65]

Table 4.1: neurodivergent HCI Guidelines for layout, visual, and text presentation

Table 4.2 presents the HCI guidelines related to how navigation should be handled within the interface.

ID	Guideline	Source
	2 - Navigation	
2.1	Provide a simplified and consistent navigation between pages. Let it be visible all the time, and must contain simple lists of links avoiding the need of scrolling pages to see all listed items	[16, 71, 65] [20, 76, 72, 27]
2.2	Indicate on each page clearly where the user is, by using location and progress indicators	[16, 65, 20]
2.3	Present global navigation buttons (Exit, Back to home page, help) on every page. These should be clear, large, and consistent	[16, 65] [20, 27]
2.4	Avoid automatic page redirects or expiration time for tasks. The user is who should control navigation and time to perform a task	[16]
2.5	Don't use complex menus that are dynamic or use transparency	[65, 76]
2.6	Show all important features and site navigation, as opposed to within combo box drop-down areas, so the user does not need to rely on assumptions to guess whether the item exists, and how to access it.	[71]
2.7	Whenever using images in navigation, make sure that images have significant alternative text (via alt attribute) adding a textual description to textually represent images function.	[76]
2.8	Textual breadcrumbs should have text size that allows comfortable reading.	[76]
2.9	Whenever possible, structure index pages considering a logical order involving tasks sequence or structure, without requiring exclusively the alphabetical ordering	[76]
2.10	When building a site map, use of hierarchical trees containing clear texts	[76]
2.11	Avoid using mechanisms that interfere with back and forward buttons functioning.	[76]

ID	Guideline	Source
2.12	When offering internal search in your website, optimize it by aiming for the quality of the results, providing self-completion, and orthographic verification to point errors and ease correction	[76]
2.13	When writing link labels, structure labels clearly in order to keep them simple. Do not use "click here"	[76]
2.14	Use underline only for links and avoid links involving big blocks of text	[76]
2.15	Provide multi-modal navigational cues (e.g. text + graphical/visual highlight + auditory instructions + animated demonstration).	[72]
2.16	Use navigation methods, i.e. 'undo' or 'back button' to help user recover when lost.	[27]

Table 4.2: Neurodivergent HCI Guidelines for navigation

Table 4.2 presents the HCI guidelines related to the customization features that should be present to tackle the large range of characteristics from neurodivergent conditions.

ID	Guideline	Source
3 - Customization		
3.1	Allow color (background color, text color, and printing colors), text size and font customization for interface elements	[16, 65] [76, 72, 27]
3.2	Offer textual version for pages so that users can download it and print it	[16, 71, 76]
3.3	Provide options to customize the amount of elements in the interface, their arrangement and enable features personalization	[16, 27]
3.4	Provide options to customize information visualization with images, sound and text according to individual user's preferences	[16, 27]
3.5	Allow users to control presentation using their own style sheets	[65, 76]
3.6	Provide a selection of color palettes, including one with a dark background and one with a light background, and at least one low-contrast neutral-color palette option to accommodate color and contrast sensitivity.	[71]
3.7	Allow personalization of line-spacing	[65]

Table 4.3: Neurodivergent HCI Guidelines for customization

Table 4.4 shows HCI guidelines for presenting redundant information in interfaces, displaying information in multiple ways.

ID	Guideline	Source
4 - Redundant Representation		
4.1	The Website or Web application must not rely only in text to present content. Provide alternative representations through image, audio, video, or charts and ensure that they will be close to the corresponding text	[16, 71] [20, 76, 72]
4.2	Symbols, pictograms and icons should present a textual equivalent near to facilitate symbol understanding and contribute to enrich user's vocabulary	[16, 71] [76, 27]
4.3	Illustrate concepts with drawings, diagrams, photos, audio files, video clips, animations, and other non-textual media to illustrate complex text or complex ideas	[76, 72]

ID	Guideline	Source
4.4	Clearly label site elements with their purpose throughout the site, even if it seems redundant, to make navigation and site functionality easier to follow	[71]
4.5	Provide concrete examples where applicable, to accommodate difficulties in understanding abstractions or generalizations	[71]
4.6	Breadcrumbs can have snapshots helping in the task of contextualizing and remembering.	[76]

Table 4.4: neurodivergent HCI Guidelines for redundant representation

Table 4.5 displays HCI guidelines for effectively engaging neurodivergent users in an interface.

ID	Guideline	Source
	5 - Engagement	
5.1	The general design and the structure should be simple, clear and predictable, secondary content that distracts the user should be avoided. In case you use it, provide options to suppress those elements on screen	[16, 71] [65, 20]
5.2	Design interfaces with few elements and which present only the features and content need for the current task to be performed by the user. Avoid tangential information	[16, 65, 72]
5.3	Provide clear instructions and orientation about tasks to ease the user understanding of the content and the content language, in order to stimulate, motivate and engage the user. Avoid long explanation phrases. Use active voice instead of passive voice	[16, 71] [65, 76]
5.4	Explain the reason behind any nonstandard instructions or unusual information; provide additional pragmatic context to accommodate difficulties with language pragmatics.	[71]
5.5	Use blank spaces between Web page elements to separate different contents or focus the user attention on a specific content	[16]
5.6	Make content as concise as possible without sacrificing precision and specificity, to reduce cognitive burden.	[71]
5.7	Use visual indicators for time-consuming actions	[65]
5.8	Icons, images and label of menus and actions should be compatible to real world, representing concrete actions and everyday life activities in order to be easily recognized	[16]
5.9	Avoid background sounds that distract the user's attention (e.g. background music).	[16, 72]
5.10	Use FAQ formats to organize complex information to enhance clarity as to why the information might be useful to the user and how it connects to their life.	[71]

Table 4.5: Neurodivergent HCI Guidelines for engagement

Table 4.6 displays HCI guidelines for how interactive elements in an interface should look and work.

ID	Guideline	Source
6 - Interaction		
6.1	Use clear, large buttons with both icons and text	[16, 65]
6.2	Do not use many-colored icons	[65]
6.3	Avoid buttons with icons only, except for the most popular actions	[65]
6.4	Don't set short "expiration" times on content. If expiration times are necessary allow the user to request more time	[72]
6.5	Ask users to confirm choices	[72]
6.6	Use shorter, multi-step forms for complex interactions, rather than lengthy, all-in-one forms	[72]
6.7	Ensure that similar interface elements and similar interactions produce predictably similar results	[16, 20]
6.8	Touch screen interactions should have the appropriate sensibility and prevent errors in selections and accidental touch in interface elements	[16]
6.9	Provide alternatives to definitive response items on surveys and forms, such as, "do not know," "do not wish to say," or "not applicable," to reduce frustration for not being able to produce an exact answer.	[71]
6.10	Provide feedback to confirm correct actions or alerting about potential mistakes and use audio, text, and images to represent the message, avoiding icons with emotions or facial expressions	[16, 27]
6.11	Present appropriate instructions to interact with interface elements, provide clear messages about errors and provide mechanisms to solve the errors	[16]
6.12	Allow critical actions to be reverted, canceled, undone or confirmed	[16]
6.13	In interactive lessons and educational activities, it is recommended allow up to five attempts before showing the correct answer	[16]

Table 4.6: Neurodivergent HCI Guidelines for interaction

Table 4.6 displays HCI guidelines for how multimedia elements in an interface should be presented.

ID	Guideline	Source
7 - Multimedia		
7.1	Allow images magnification for better visualization and ensure they continue to be understandable when enlarged	[16]
7.2	Provide information in multiple representations, such as text, video, audio and image for better content and vocabulary understanding, also helping users focus on content	[16, 76]
7.3	Whenever counting on videos or audios, do not play these media automatically when the page loads. Provide video or audio only under users' requests.	[76]
7.4	Provide audio instructions and subtitles for texts, but ensure that this is not the only alternate content representation	[16, 72, 27]

Table 4.7: Neurodivergent HCI Guidelines for multimedia

4.4 Creativity Techniques

The number of existing creative techniques is plentiful. A large number of different techniques can be found spread around literature as we referred to in subsection 2.1.5. As the name implies, Creative techniques refer to methods/techniques that support creativity and the generation of novel ideas.

In this section, we want to look at well-known and not-so-known techniques and, by taking into account what we have searched about neurodiversity conditions so far, reflect on what are the most appropriate ones for those individuals. In the case they aren't, we also want to consider what could be changed about them, so that they can be more accessible. There is a reason why we are not just collecting techniques to add to our goal modeling tool. It stems from the fact that, even though neurodivergent people are prone to be creative by definition due to their non-conventional way of thinking, visual thinking (especially in the case of dyslexics), and extensive knowledge due to hyper-fixations (prone in autistic individuals), there are also some limitations that we should consider. In this way, we hope to reach a balance between both strength-based approaches and accessibility in our tool.

4.4.1 Creative techniques and neurodivergent struggles

We already have pointed out some difficulties that neurodivergents face in their lives in subsection 2.2.2. Now we will return to those struggles and infer in which ways they can affect the use of creative techniques.

Struggle 1: Social Isolation
Neurodivergent individuals, especially those who are autistic or those who have ADHD, might have problems socializing with other people, be it from their struggle to communicate or understand certain social cues or from society's stigma towards neurodivergence. This can oftentimes lead to isolation. When it comes to creative techniques, a lot of techniques are presented as group efforts. While making the effort to be inclusive and diverse in group activities is important and even beneficial [10], it is worth considering prioritizing what creative techniques can be done individually, which gives space for neurodivergent individuals to think on their own terms freely.

Struggle 2: Abstract Thought
Those who participate in creative techniques are often encouraged to think about a problem in a broad sense and to see the big picture rather than the details. This can be an issue if the participant is neurodivergent, as the lack of some input to focus on for a certain topic can make the individual feel empty-handed as they do not have any starting point on which they can pinpoint. This is a very noticeable problem in the case of autism. For that reason, it is important to think about how we can keep the freedom found in creative

techniques while also adding some specificity and rules to them giving more context and groundwork for neurodivergents to apply their strengths to generate new ideas.

Struggle 3: Predictability And Distractions
Creativity is in its nature a very free-flowing process and it is in this setting that the best ideas come from [32]. To neurodivergent individuals, this less restrictive environment can actually lead to some barriers. For example, autistic individuals a lot of times desire some form of rules to follow and to know what each step will entail beforehand. In the case of people with ADHD, they can get too distracted if there are too many things to consider at once, meaning there should be careful consideration of how much information and tasks should be shown at a time.

Struggle 4: Reading/Writing Difficulties
This struggle is most prominent for those with dyslexia, as they have difficulties in reading and writing text. Having certain accessibility features such as text-to-speech ready interfaces or font options for size and font can remediate this issue. Still, it should be worth considering what creative techniques require less reading/writing and are more reliant on visual thinking.

Keeping these struggles in mind, we will now proceed with a selection of techniques in 4.4.2 with the following questions as criteria:

- Can the technique, to be further developed, be easily implemented as an extesion of iStar?
- Can the technique be done individually, rather than require a group of people?
- Does the technique follow a more systematic approach rather than an open-ended one?
- Does the technique rely on a lot of reading/writing?

4.4.2 Neurodivergent-inclusive creative techniques classification

Returning to the literature review of creative techniques [26] we mentioned in the background (in subsection 2.1.5), which describes 30 techniques, we will now analyze which ones we believe are the most fitting for neurodivergent individuals. We also gathered some other techniques from another source we found through Google when searching for "*Creative Techniques*", the *Creating Minds* website [84], which focuses on giving information on creativity and includes a page with descriptions of idea-generating techniques. We gathered 44 techniques in total from both sources. The names and descriptions of each technique can be found in Appendix A. We then applied the exclusion criteria, based on

the criteria questions from subsection 4.4.1, with the following questions to know what techniques we would want to implement in the tool:

- Does the technique have a guided/systematic approach?
- Can the technique be done individually?
- Can the technique be easily implemented in iStar?

If the answer to any of these questions is no, then we exclude the technique as it would not be accessible to neurodivergent individuals and would not translate easily to a goal modeling tool to use individually.

After applying the exclusion criteria, based on the struggles associated with using creative techniques that we mentioned before in this section, we evaluated the appropriateness of each technique for each neurodivergent technique we are considering in this thesis (ASD, Autism, and Dyslexia). We thought that this is an important distinction to make since there are distinct struggles between each condition.

We use the following classification in terms of appropriateness:

- Two plus (++) means that we believe the technique to be a perfect match for that condition;
- One plus (+) means that we believe the technique is a good match but one or another aspect might need some adjusting;
- One minus (−) means that we believe the technique could still be used by the individual but with some struggle;
- Two minus(−−) means that we believe the technique to not be fitting at all with the condition.

Table 4.4.2 shows our evaluation of each of the techniques in terms of appropriateness. For autism, the more guided and input-based the techniques were the more fit they were to us. For ADHD, we looked at how structured the techniques were. We wanted techniques that required less reading (those that use various questions we feel would be harder to use with dyslexics) and more visual thinking. The fact that Brainstorming does not really require any reading, was the reason why we made an exception from the exclusion criteria, despite not really being a systematic technique and being quite open-ended. We believe that for that reason it makes for a great match with dyslexics.

Technique	**Appropriateness**		
	Autism	**ADHD**	**Dyslexia**
Brainstorming	−	−	++
Goal modeling	+	+	+

Roles playing	+	+	++
Hall of fame	++	+	−
Viewpoints	++	+	−
Questions list (SCAMPER)	++	++	−−
Heuristics	+	+	++
Why why why?	++	++	+
Assumption−busting	++	++	++
Attribute Listing	+	+	+
Breakdown	+	+	−−
CATWOE	+	+	−−
Day In The Life	++	++	++
The Kipling method (5W1H)	++	++	−−
How to	++	++	+
Is − Is not	+	+	+
PSI	++	++	+
Random Words	++	+	−

Table 4.8: Appropriateness of creative techniques for different neurodivergent conditions

4.5 iStar Extension For Creative Requirements

iStar is the goal-modeling language that we choose to use for our neurodivergent-inclusive approach to Software Engineering. As we stated previously in subsection 2.1.4, the iStar language is prone to extensions due to its open nature. When developing our solution, we wondered how we could bridge the use of creative techniques, where engineers can elicit ideas that then could be transformed into requirements, and document said requirements in iStar. This is where our *i* extension for creative requirements* comes in.

When having a certain idea that can be potentially added to an iStar model, the analyst (the name of those who create an iStar model) has to implement that idea immediately into the model itself. With our extension, we want to have a "middle step" where the analyst can first analyze what relations or elements that idea could be without having it be definitive. This section will guide you through the process of making and explaining the extension by using the PRISE process for creating iStar extensions [29].

4.5.1 Analyse The Need For Extension Proposal

Study a domain/application area

It was not necessary to contact experts in the domain/application area in this task, since this extension is related to practical aspects of the usage of iStar and it was not based on a set of concepts defined in references.

Identify the concepts to be introduced by the extension

We identified 4 concepts to be introduced by the extension, being 1 node and 3 links, as shown in Table 4.9.

The concept of an *Idea node* was created with the aim of being able to seamlessly translate and represent a generated idea from a creative technique into the model. This new node serves as a "blank slate" for any possible representation of that idea within the model. By having this node, the analyst does not need to immediately represent their ideas to concrete iStar elements. Rather, they can first think about their purpose within the model and their relation to other Actors and Intentional elements.

To help the analyst better understand the relation of an Idea node and other elements of the model, we decided to also add the *Association* and *Affect links*. The Association link gives a connection of an Idea to an actor it most closely relates to. As for the Affect links, these helped the analyst understand the effect the ideas might have on existing Intentional elements. We have two types of them: *Motivates*, and the one with opposite effect, *Restricts*.

ID_concept	Name of the Concept	Reference
	Nodes	
CON_CR_01	Idea	-
	Links	
CON_ CR _02	Association	-
CON_ CR _03	Motivates	-
CON_ CR _04	Restricts	-

Table 4.9: Concepts to be introduced in the extension

Contact experts and model an example with the identified concepts using iStar

We did not have any doubts about the domain/application area, so we did not contact these experts. We also did not have any doubts about which domain concepts are possible to represent with iStar without creating new representations, and which are not possible to identify with iStar.

Search if there is an extension related to the new proposal in iStar extensions catalogue

We tried to search for extensions in the repository [39] using the terms *idea*, *creativity*, and *creative* of which no results were returned, meaning there is no extension proposed for

this purpose.

4.5.2 Conceptualise The iStar Extension

Search and select constructs to be reused

We did not find any construct in the repository [39] to be reused.

Define extension's concepts

The extension's concepts are defined in Table 4.10.

ID_concept	Name of the Concept	Definition	Reference
		Nodes	
COM_CR_01	Idea	Represents an idea to solve/implement a certain aspect from the model of which its generation was based on creative techniques.	-
		Links	
COM_ CR _02	Association	Relationships between idea and actor where an idea is associated with an actor.	-
COM_ CR _03	Motivates	Relationships between idea(s) and/or intentional elements (goal, quality, task, and resource), where an idea motivates an intentional element or another idea.	-
COM_ CR _04	Restricts	Relationships between idea(s) and/or intentional elements (goal, quality, task, and resource), where an idea restricts an intentional element or another idea.	-

Table 4.10: Definition of the extension's concepts

Analyse how the extension constructs can be integrated with the iStar constructs

We tried to relate the concepts to be introduced with the iStar standard concepts. So, we concluded that Association links connect Idea nodes to Actors and that Motivates and Restricts connect Idea nodes to Intentional Elements, as shown in Table 4.11.

ID_concept	Name of the Concept	Relation with iStar constructs
	Links	
COM_ CR _02	Association	It can connect Ideas to Actors.
COM_ CR _03 COM_ CR _04	Motivates Restricts	It can connect Ideas to Intentional Elements.

Table 4.11: Extension constructs' integration with iStar

4.5.3 Develop iStar Extension

Define the metamodel of the extension

We included the concepts identified in the List of concepts to be introduced in the iStar metamodel. We considered the relationship between the extension's constructs and iStar constructs in this step. The result is presented in the Figure 4.2. The new metaclass *Idea* was created, which is linked to the *Intentional Element* metaclass through a new link type that we are calling *Affect Type*, which includes the *motivates* and *restricts* links, and to the *Actor* metaclass through the new *Association* link. It was not necessary to add validation rules in this extension.

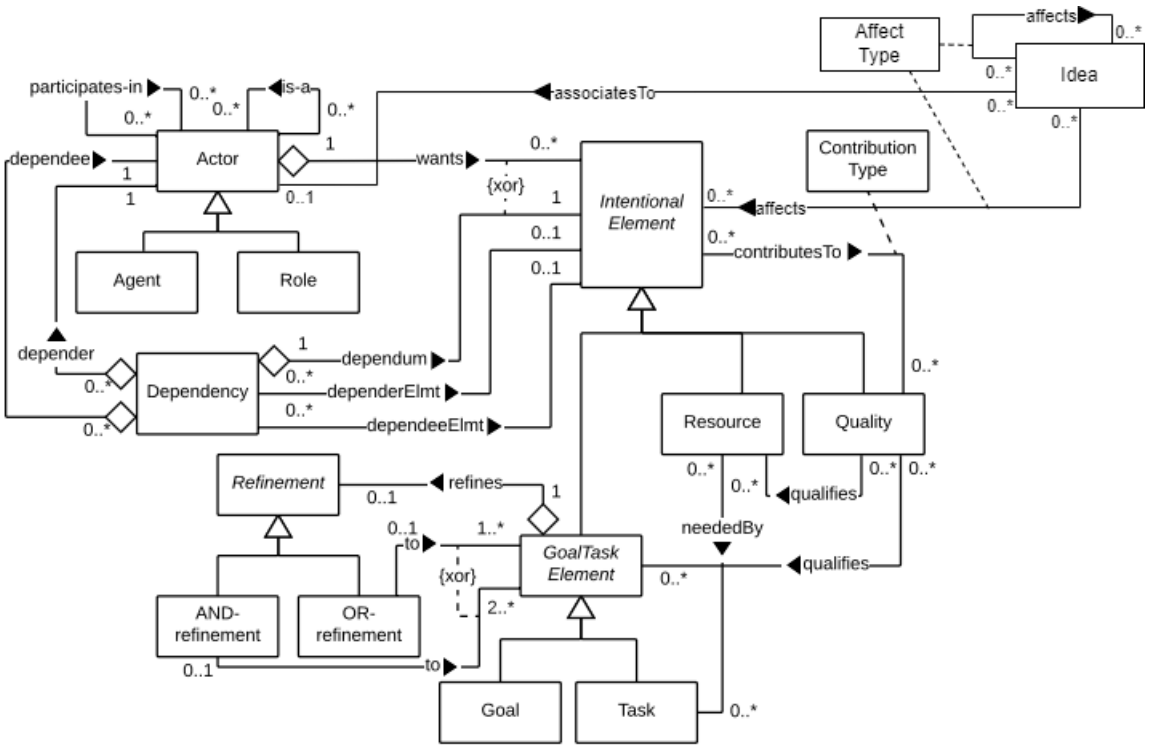


Figure 4.2: Extension's metamodel

Define concrete syntax of extension

The representations of the extension's constructs as well as a description of each of them are presented in Table 4.12.

ID_concept	Name of the Concept	Representation	Explanation about the graphical representation	Reused?
Nodes				

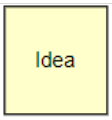
COM_CR_01	Idea		Square-shaped figure to distinct from resource elements and yellow color based on post-it papers.	No
Links				
COM_CR_02	Association		It's an arrow with an open head and text that shows what actor an idea relates to.	No
COM_CR_03	Motivates		It's a dashed arrow with an open head and text that shows how an idea motivates an intentional element/idea.	No
COM_CR_04	Restricts		It's a dashed arrow with an open head and text that shows how an idea restricts an intentional element/idea.	No

Table 4.12: Concrete syntax of the extension's concepts

Check completeness, consistency and conflicts

To make sure that the developed extension has been well conceptualized while still in line with the baseline concepts from the iStar language, we did a check on its completeness, consistency, absence of nodes and links from the default syntax, and potential conflicts. As it can be seen in Table 4.13, our extension passes all the necessary checks to make it well-rounded.

Completeness			
Which level the iStar extension was applied			
[X] Concepts definition	[X] Metamodel	[ ] Well--formedness rules	[X] Concrete syntax

Consistency			
List following the concepts in each level			
Concept	Concept's definition	Metamodel	Concrete syntax
Idea	[X]	[X]	[X]
Association	[X]	[X]	[X]
Motivates	[X]	[X]	[X]
Restricts	[X]	[X]	[X]

Absence of nodes and links of iStar default syntax			
Construct		Metamodel	Concrete syntax
Goal		[X]	[X]
Quality		[X]	[X]
Resource		[X]	[X]
Task		[X]	[X]
Actor		[X]	[X]
Agent		[X]	[X]
Role		[X]	[X]
Refinement		[X]	[X]
Qualification		[X]	[X]
Contribution (make, help, break, hurt)		[X]	[X]
NeededBy		[X]	[X]
Dependency		[X]	[X]
Association links	is-a	[X]	[X]
	Participates-in	[X]	[X]

Conflicts				
List the concepts and verify the occurrence of conflicts between the constructs of the extension and the existing extensions.				
Concept	Conflicts			
	One construct with two or more Symbols	Two of more constructs with only one Symbol	Wrong representation of iStar constructs	Construct which is not part of the extension
Idea	[0]	[0]	[0]	[0]
Association	[0]	[0]	[0]	[0]
Motivates	[0]	[0]	[0]	[0]
Restricts	[0]	[0]	[0]	[0]
Details about the problem(s): No problems were identified				

Table 4.13: Completeness, consistency and conflicts check for the extension

Apply the extension to a modeling tool

This extension is being used in a modeling tool with added features for creative techniques and accessibility for neurodivergent individuals which we will detail in Chapter 5.

4.5.4 Questions And Answers About The Extension

For added clarity, in this section, we present some questions relative to our extension and some details not presented during the PRISE process.

What is the main purpose of this extension?
This extension aims at complementing the existing i* language to include elements that can help strive for creativity to add new and exciting elements that might not have been considered before. This extension is to be used along with creative techniques such as Brainstorming, Hall Of Fame, Pair Wise, and other idea-generating ideas. In the end, the extension will be the bridge between creative techniques and the i* language to facilitate the generation of new and creative requirements through a more systematic process.

How to transform the extension elements into i* elements?
After using creative techniques, the various ideas generated from them should be transformed into idea nodes. Then, the analyst should cluster the ideas into different groups. When that is done, the analyst can start linking the Idea nodes to either intentional elements or other ideas by using the Affect type links and link the Ideas to Actors using the Association link. Finally, with all of the connections done, the analyst can use them to infer new i* elements. These can become new actors, dependency relationships, refinements, or any other element from the iStar syntax.

What's the benefit of using the extension over just using the regular i* elements?
The creative process can be quite unstructured and unfiltered to obtain novel results. Our extension aims to let the user feel free to add as many new and creative solutions as they can without the need to worry immediately about how they relate it to the rest of the model. Instead, the extension itself reveals as a middle point where the analyst is still figuring out both the usefulness of said idea and its relationship with the model itself. The idea node encapsulates any type of element and/or link in the i* language while the new links in the extension help to show the possible connections to the model without affecting what's already there. In resume, the extension gives more freedom to the analyst to be creative with the elicitation of requirements, while making it said process more systematic with a minor risk of affecting what has been already developed before.

Can the extension be used for both SD and SR view models?
This extension pretends to find new ideas that weren't thought of initially by the analyst developing the model. Usually, those ideas might go to more detail-oriented aspects of the problem being solved. Due to the more detailed view of SR models, the extension will work more effectively in that view for that reason. However, there's nothing stopping the analyst from using the extension in the initial phase of an SD model to gather the main actors and dependencies of a model.

4.5.5 Validate iStar extension

Use the iStar extension proposed to model a system

This extension can be used either when an iStar model has or hasn't been started yet, although it works best when there's at least a basic model to use it with. Idea nodes can be generated through various creative techniques such as Brainstorming, Hall of Fame, and others. After that, those nodes can be clustered into groups if such an exercise can be applied to that node. Then, affect and association links can be added to the model to connect ideas nodes to other elements of the model. Having done that process to all the idea nodes, those new relations can now be transformed into iStar elements, by thinking about what new elements and relations can be created through it based on the additions to the model by the extension. The recommended process to use this extension is summarized in the following steps:

1. Choose any creative technique of your linking;
2. Generate ideas using the selected technique which will now be passed as Idea nodes;
3. For each idea that you believe might have the potential to be represented in the model, do the following steps:
   - 3.1 If it applies, connect an idea to the most related actor using an Association link type;
   - 3.2 Consider how the Idea node affects other Intentional Elements or even other Idea nodes and connect to them using an Affect link type, which can be either motivates or restricts;
   - 3.3 Finally, look at your established connections between Ideas and the other elements of the model and think about what kind of iStar elements and links they can be turned to.

In order to make the previously described process clearer, we start with a toy example based on the University Travel Reimbursement Scenario from the iStar 2.0 guide [18]. Initially, in Figure 4.3 we have a single dependency between the two actors of the model, the Student and the Travel Agency. The Student wants to have a travel bundle booked which can be achieved through the Travel Agency. Then, in Figure 4.4 there are two ideas added to the model. We now want to *Allow for customization of bundle* and *Users desire for easy and quick booking*. The first idea is mostly achieved through the Travel Agency (meaning it's heavily *associated* to it) and *motivates* the *Bundle booked* Goal from the Student actor. This first idea *restricts* the second one, as having customization options takes more time and is a more complex process for the user than just having pre-made options. The second idea is, as the use of *Users* implies, more closely *related* to the Student actor. The first idea is transformed into a new dependency related to booking bundles, whereas the

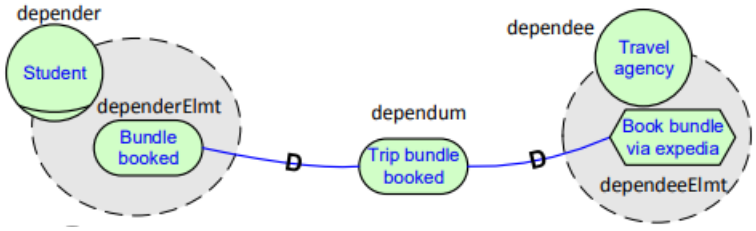


Figure 4.3: Base i* model taken from i* 2.0 guide

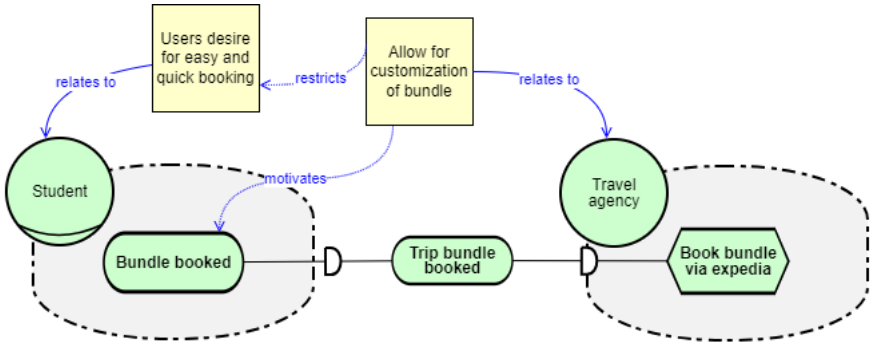


Figure 4.4: Extended model with two ideas

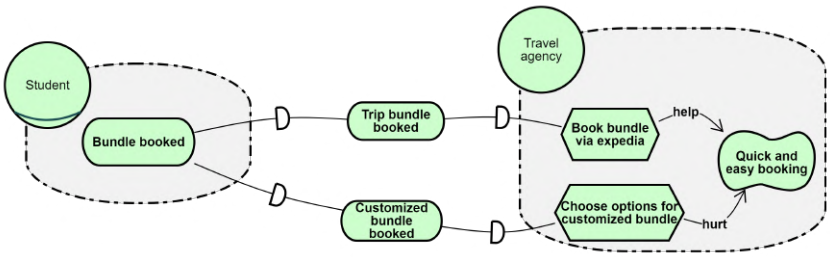


Figure 4.5: Final model with transformed ideas into i* elements

second idea originated a new quality within the Travel Agency boundary about quick and easy booking, as shown in Figure 4.5.

Please note that this is just one interpretation of the Idea nodes and their associated links, different iStar elements and links could originate from them. That's the creative liberty found in the Idea nodes as they can be a blank slate for a new iStar element.

To show that it is possible to use the extension on its own without using other iStar elements, we present an example of such an occasion in Figures 4.6 and 4.7 of a Travel Planner App.

As an example of the usage of this extension in a more complete setting, we used the full Travel Reimbursement Scenario from the iStar 2.0 guide [18]. The complete description of this example in the guide reads: " Students must organize their travel (e.g., to conferences) and have several goals to achieve, and options to achieve them. To achieve their goals, students rely on other parties such as a Travel Agency and the university's

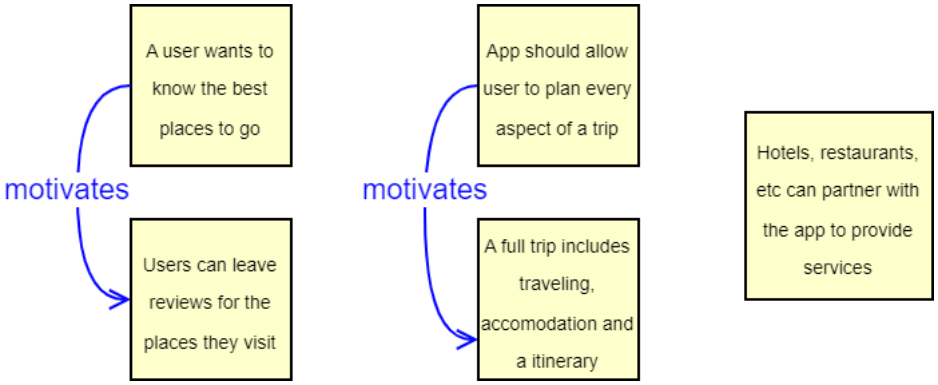


Figure 4.6: Initial model with only Idea nodes and Affect links

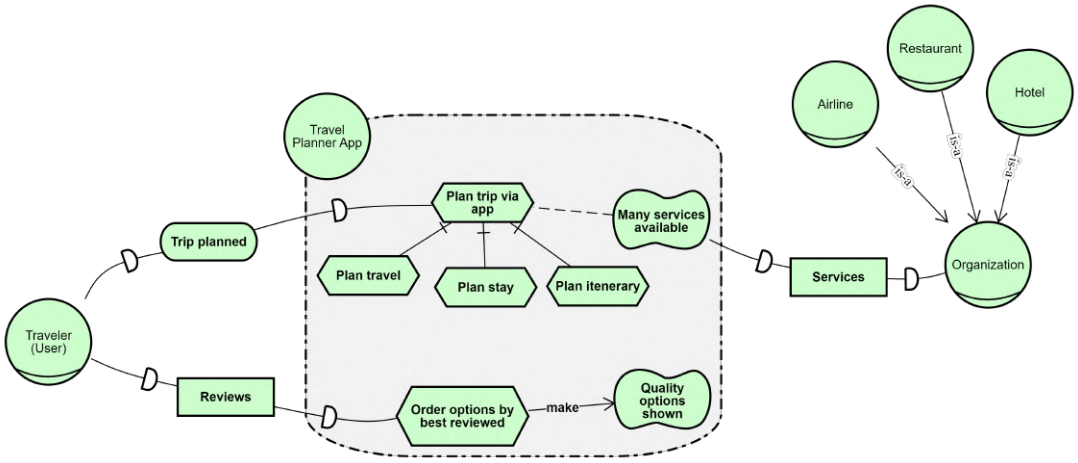


Figure 4.7: Final model with transformed ideas into i* elements

trip management information system". This example demonstrates how, even in a more complete and complex example, our iStar extension is able to produce new requirements based on pre-existing ones.

First, we have the initial example taken from the guide as shown in Figure 4.8. Then, we add four Idea nodes to the model and make connections with them as shown in Figure 4.9. Finally, we turn those nodes into iStar elements and links as shown in Figure 4.10.

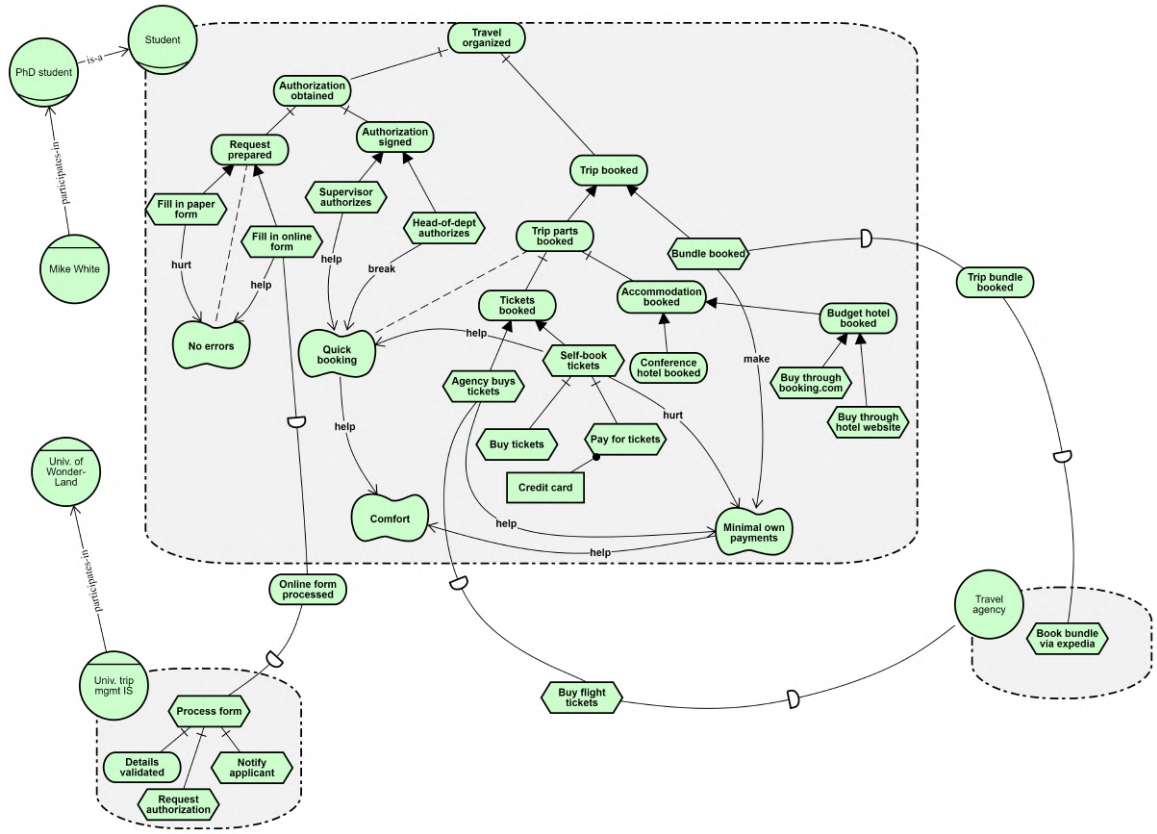


Figure 4.8: Full Travel Reimbursement Scenario from the iStar 2.0 guide

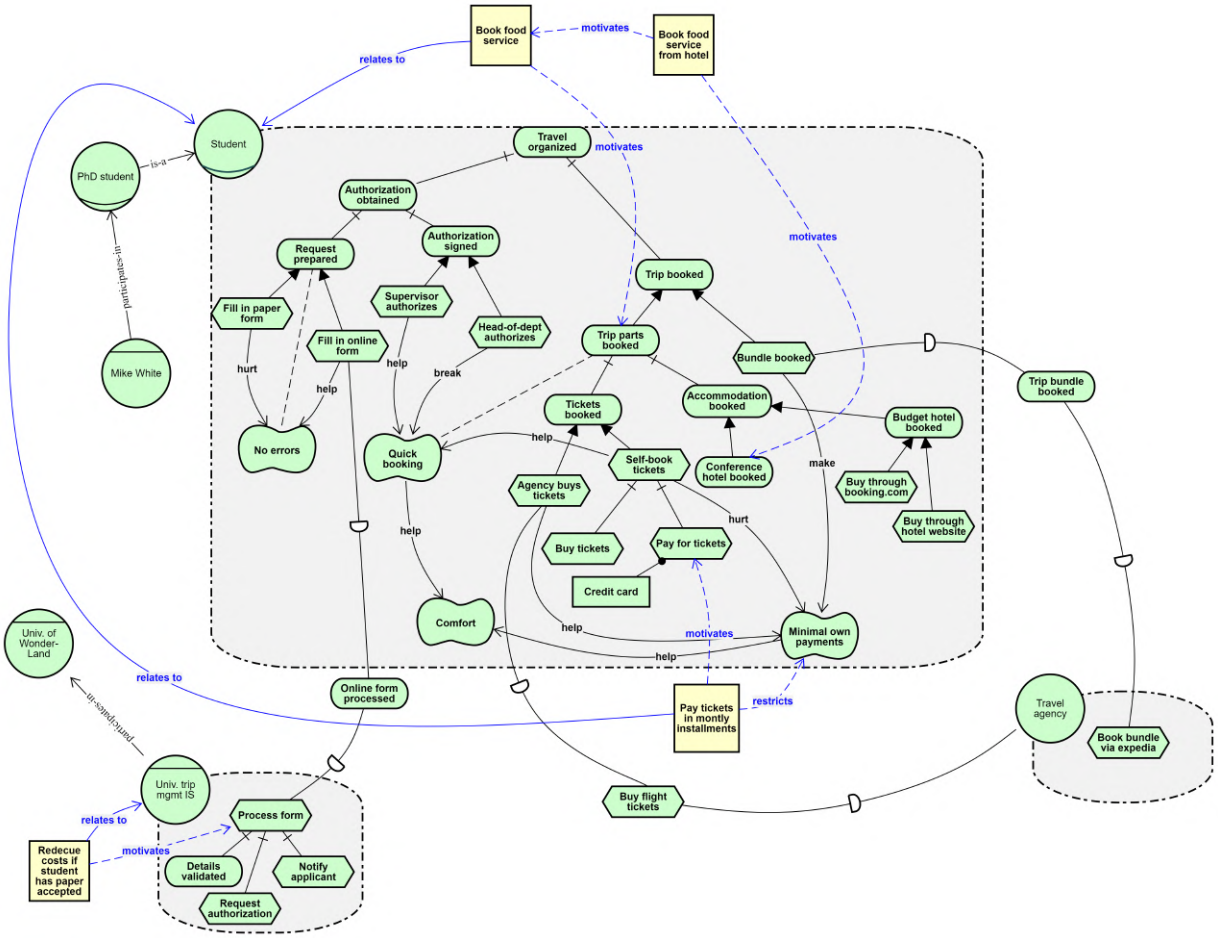


Figure 4.9: Extended model with three new ideas

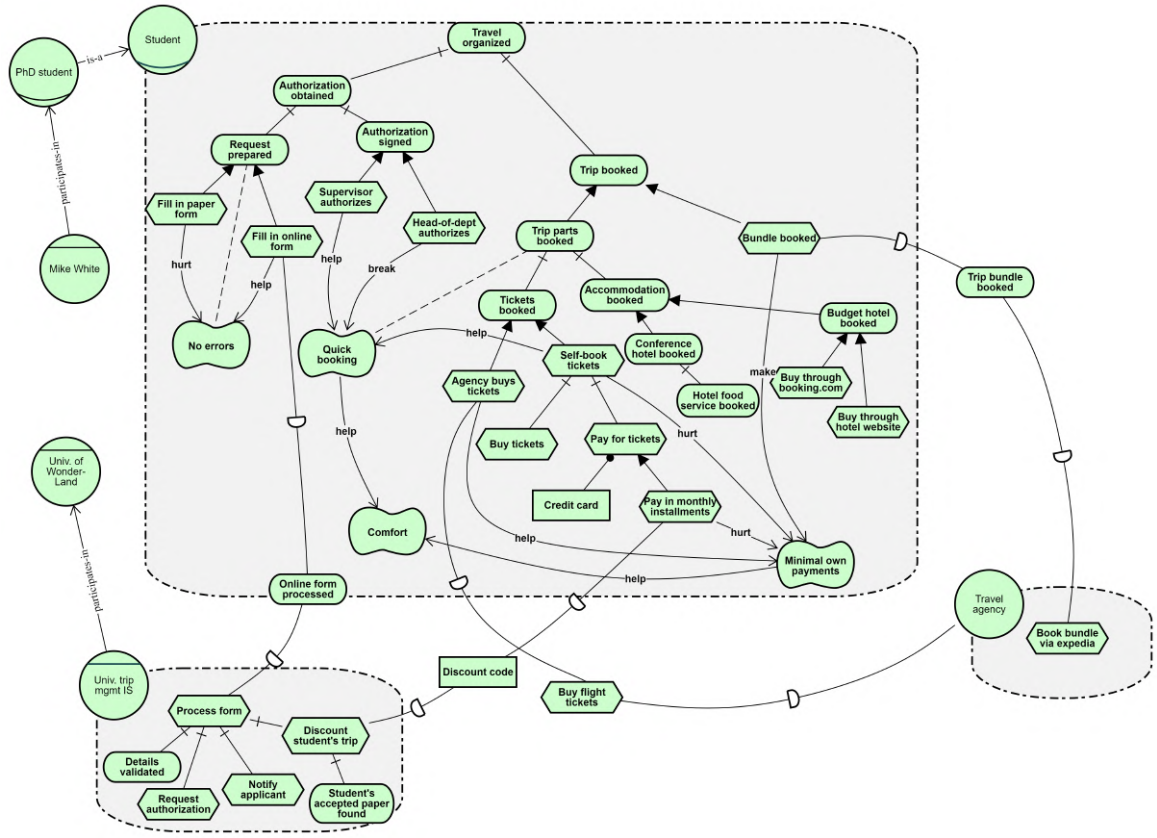


Figure 4.10: Final model with transformed ideas into iStar elements

Evaluate the iStar extension

The evaluation of this iStar extension was done through a questionnaire detailed in Chapter 6.

4.6 Summary

In this chapter, we developed the main concepts that form our neurodivergent-inclusive approach for requirements engineering, specifically for the elicitation and analysis phases. We first make note of how we shifted from the software engineering field towards just specifically requirements engineering. Then, we described an outline for our proposed solution which will result in a goal modeling tool.

This solution stands by three main topics. The first is neurodivergent HCI guidelines which we gathered a set of them to follow when developing the tool to cover the design of the UI's layout, navigation, customization, redundant representation, engagement, interaction, and multimedia.

The second topic is about creativity techniques we gathered and classified many of them in terms of accessibility to neurodivergent individuals based on their struggles and strengths.

Finally, the third topic refers to the iStar extension we developed to more harmoniously use creativity techniques for a goal modeling setting. This extension was developed systematically using the PRISE process.

5

IdeaStar - A neurodivergent-Inclusive Goal Modeling Tool

The present section will detail the resulting tool of our approach, *IdeaStar*, that culminates its three main topics: HCI neurodivergent-inclusive guidelines, creative techniques for neurodivergent individuals, and an iStar extension for creative requirements.

IdeaStar is a web-based goal modeling tool for the iStar language, based on the piStar tool[1] shown in Figure 5.1, which is open-source. Like the tool it is based on, IdeaStar allows to create and load iStar models following most constraints from the iStar language 2.0 guide [18]. However, our tool has new features that aim to bring accessibility to neurodivergent users, such as added options to alter the look of the diagram, new nodes and links courtesy of our iStar extension, and neurodivergent inclusive creative techniques to help generate idea nodes for the model. A similar iStar goal modeling tool that also uses creative techniques to elicit new requirements was found after our systematic review, that being Creative Leaf[2], shown in Figure 5.2 by Jennifer Horkoff et all [34]. Our tool extends the concepts present on Creative Leaf with the previously mentioned features that make it accessible to neurodivergent individuals. A snapshot of IdeaStar can be seen in Figure 5.3. The source code of IdeaStar is available on GitHub[3].

5.1 Accessibility Options

Firstly, we show the accessibility options that we added and were not present in piStar, those being the ability to change the background color for the diagram and to change the elements. These features are found under the *Options* tab as shown in Figure 5.4.

For the background color option, the user is free to select any color they desire, although there are five presets, based on guidelines 1.20 (from Table 4.1), 3.1 and 3.6 (from Table 4.3), as shown in Figure 5.5. Figure 5.6 shows an example of the effect of using this option, where the chosen color is #FFFFE5.

[1] https://www.cin.ufpe.br/~jhcp/pistar/
[2] https://creativeleaf.portal.chalmers.se/
[3] https://github.com/abia22/iStar_NDI_Accessability_Tool_

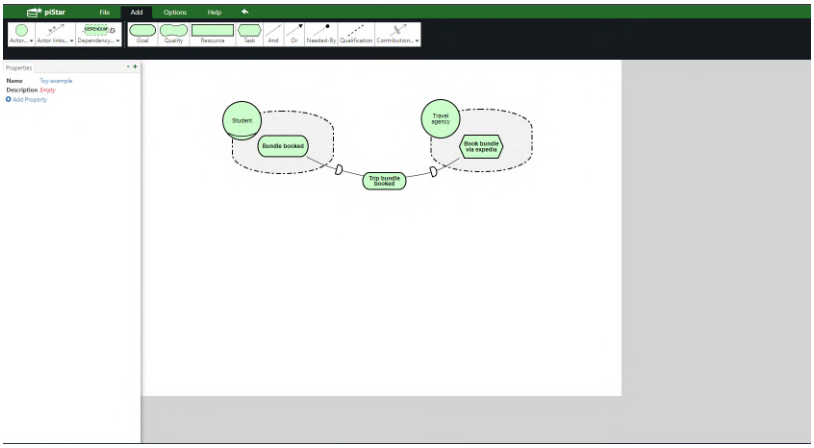


Figure 5.1: Snapshot of the piStar tool

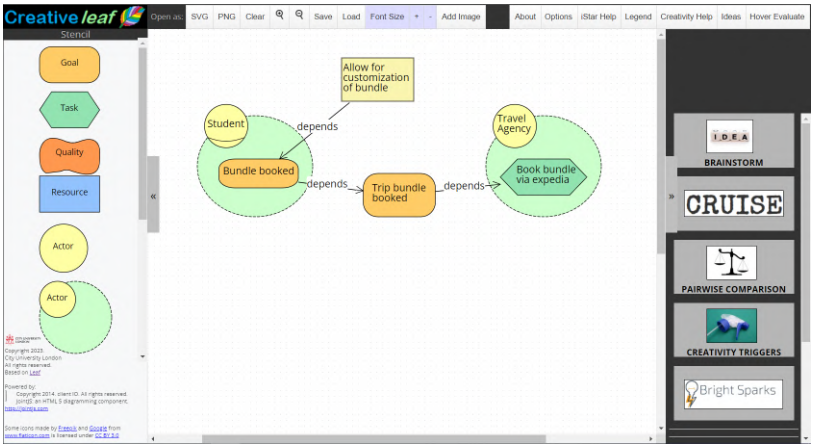


Figure 5.2: Snapshot of the Creative Leaf tool

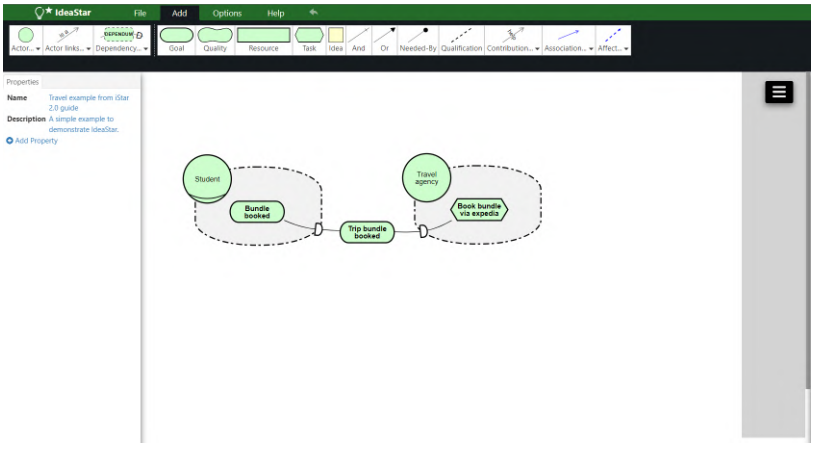


Figure 5.3: Snapshot of the IdeaStar tool

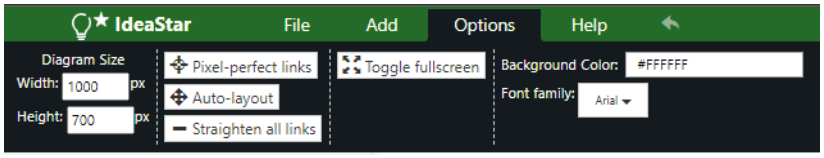


Figure 5.4: Options tab of IdeaStar, the added features are placed on the far right side

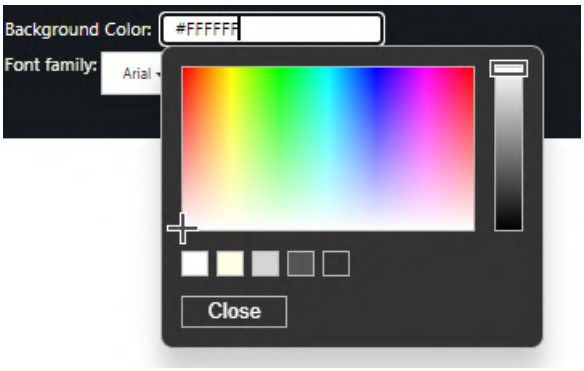


Figure 5.5: Background color option

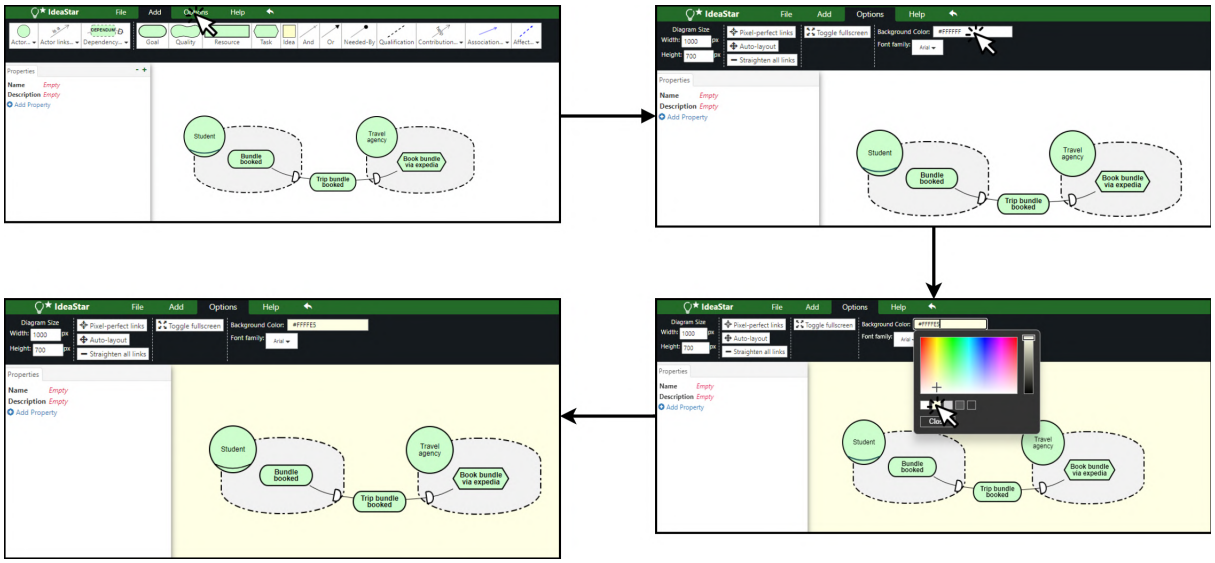


Figure 5.6: An example of the usage of the background color option

The other option we added was to change the font of the diagram's elements. Based on the suggestions from guidelines 1.2 (from Table 4.1) and 3.1 (from Table 4.3), the available fonts are the following: *Arial*, *Verdana*, *Tahoma*, *Trebuchet*, *Georgia*, *Comic Sans*, as shown in Figure 5.7. Figure 5.8 shows an example of the effect of using this option, where the chosen font is Georgia.

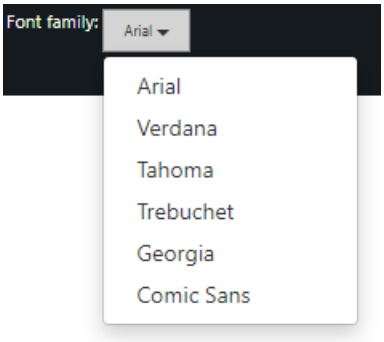


Figure 5.7: Font-family option

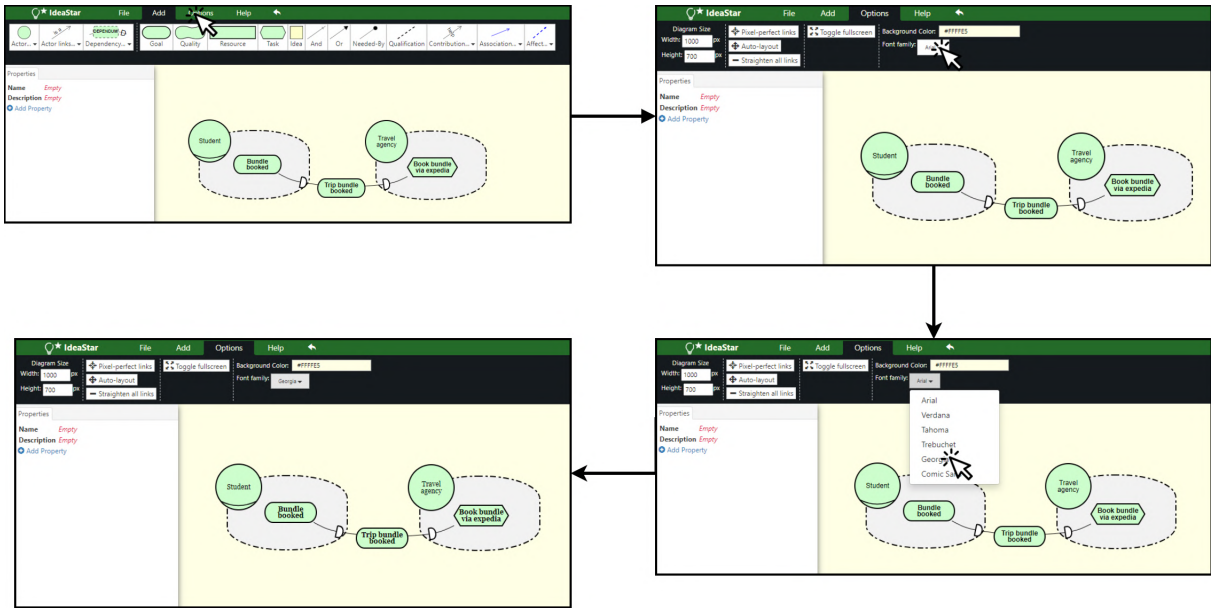


Figure 5.8: An example of the usage of the font-family option

5.2 The New iStar Elements

As explained in section 4.5, an extension to support the use of creative techniques was needed, which means that new iStar elements not present on piStar were added to the *Add* tab, those being Idea nodes, Association links and Affect links of either type Motivates or Restricts. The use of these new elements is similar to other iStar elements/links present in piStar.

To add an Idea node, the user first needs to click on the Idea node button (Figure 5.10) then the user can click anywhere on the diagram's canvas to place the node. To edit the text present in the Idea node, the user has to click on it twice to open a pop-up with an input box for that effect. Figure 5.13 shows an example of adding and changing the text of an Idea node using the same iStar model as the one in the toy example described in Sub-Subsection 4.5.5.

Figure 5.9: Add tab of IdeaStar with the new elements from the iStar extension

Figure 5.10: Idea button

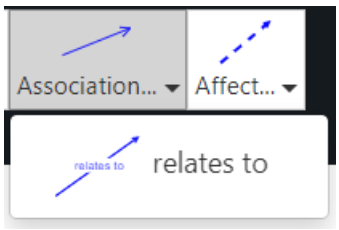


Figure 5.11: Association link button

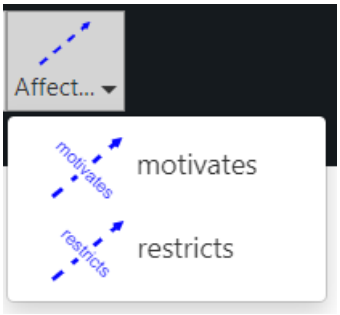


Figure 5.12: Affect link button

To add an Association link, the user first needs to click on the Association link button and then on the relates to option (Figure 5.11). Then the user clicks an Idea node and then on the Actor (in this order) to add an Association link between them. An error message will appear in these cases: the source of the Association link is not an Idea node; the target of an Association link is not an Actor; the source and the target of an Association link are the same; the selected Idea node already has an Association link. Figure 5.14 shows an example of adding an Association link to an Idea node, continuing of Figure 5.13.

To add an Affect link, the user must first click on the Affect link button and then choose either the motivates or restricts option (Figure 5.12). Then the user clicks on an Idea node and then on an Intentional element (Goal, Quality, Resource, or Task) or another Idea node (in this order) to add an Affect link between them. An error message will appear in these cases: the source of the Affect link is not an Idea node; the target of an Affect link is a Dependum; the target of an Affect link is not an Intentional element or an Idea node; there already is an Affect link between that Idea node and the target node; the source and the target of an Affect link are the same. Figure 5.15 shows an example of adding an Affect

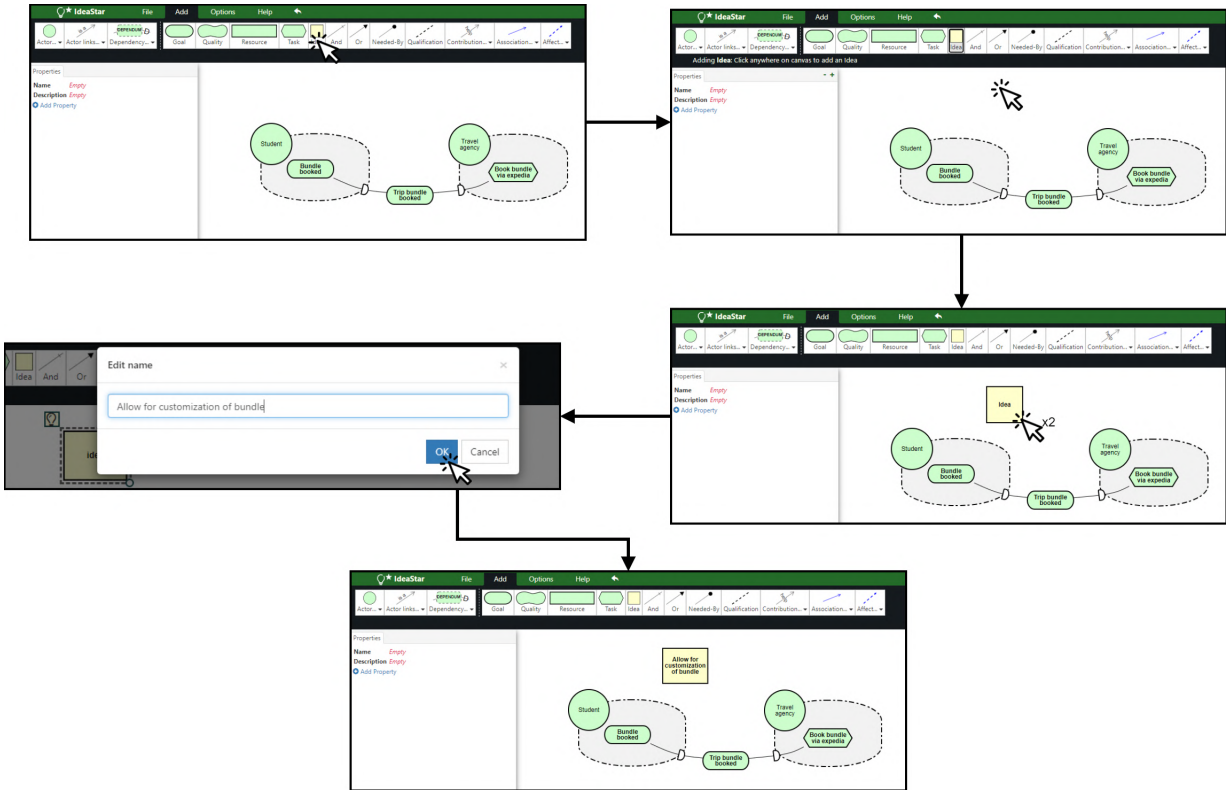


Figure 5.13: An example of adding and changing the text of an Idea node

link to an Idea node, continuing of Figure 5.14. A video showcasing how to use the Idea node, Association and Affect link is available on Youtube[4].

5.3 Creative Techniques

To help generate Idea nodes, IdeaStar features creative techniques chosen from the ones defined in Section 4.4. Due to the limited time to develop the prototype, only two were implemented:

- *Brainstorming*, due to its simple implementation that could be used as a base for other techniques, for being one of the most well-known techniques that most users might already be familiar with and for dyslexics is especially accessible for having very little text to read to use the technique;
- *Hall of Fame*, due to its heavy input-based approach to generating ideas which, from our previous research, is very aligned with autistic individuals.

The implementation of these creative techniques into IdeaStar required some adaptations to make them more accessible to neurodivergents. The following subsections

[4] https://youtu.be/CCnoWUtjc28

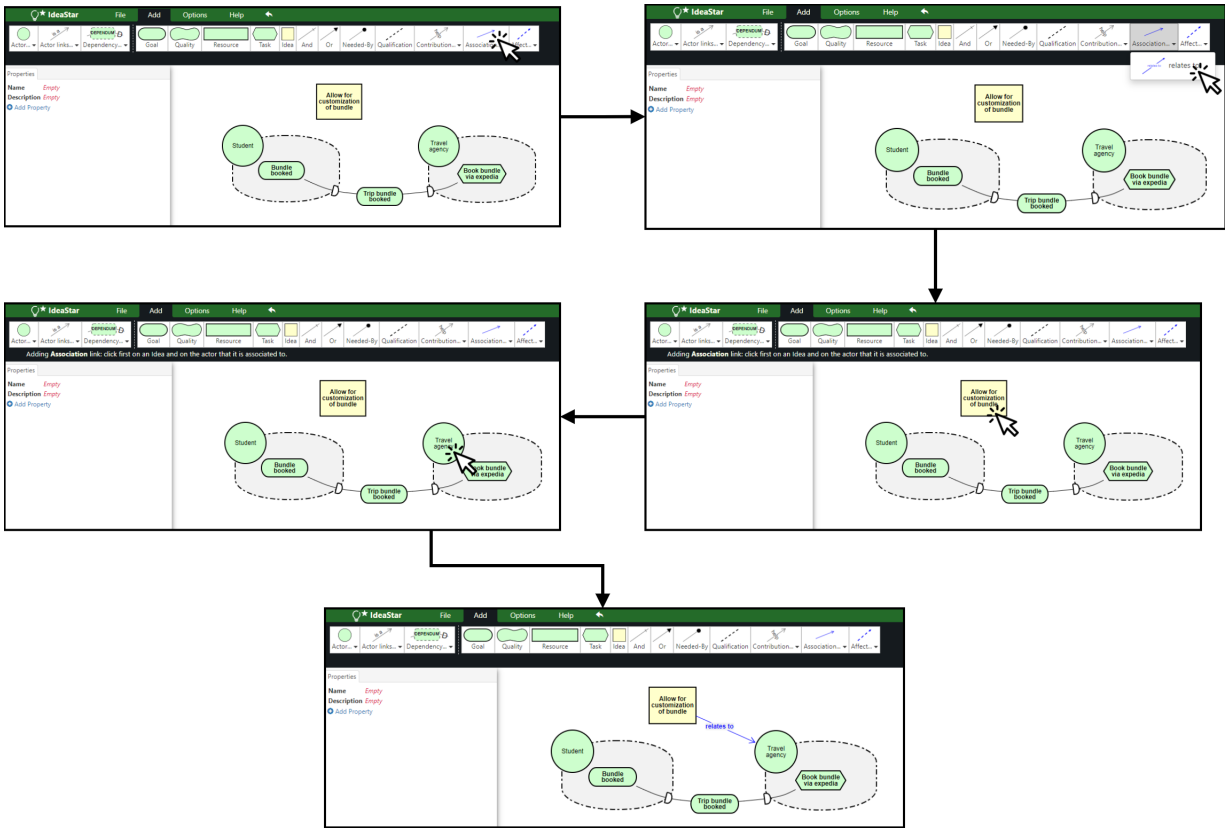


Figure 5.14: An example of adding an Association link

describe those alterations and a guide to using them in IdeaStar.

5.3.1 Brainstorming

Brainstorming is a creative technique where "*participants from different stakeholder groups engage in an informal discussion to rapidly generate as many ideas as possible without focusing on anyone in particular*" (Appendix A). Since our tool was made to be used individually, we adapted the technique in a pop-up format, needing one person only to utilize it.

To use this technique, the user must click on the hamburger-like button on the top right side of the canvas of the diagram. A menu called "Creative Techniques" will appear. When the "Brainstorm" option is clicked, a pop-up will be shown, starting a Brainstorming session. Right away, the changes and features done to the technique to make it more accessible to ND are visible:

- *Wizard-style navigation* (i.e. having different separate pages for each task). This adds clarity to the user as for how many tasks they need to do to finish and what which task will require them to do beforehand;
- *Ask for a problem/domain definition* before the main Brainstorm task. This gives a starting point instead of having this technique be too open-ended.

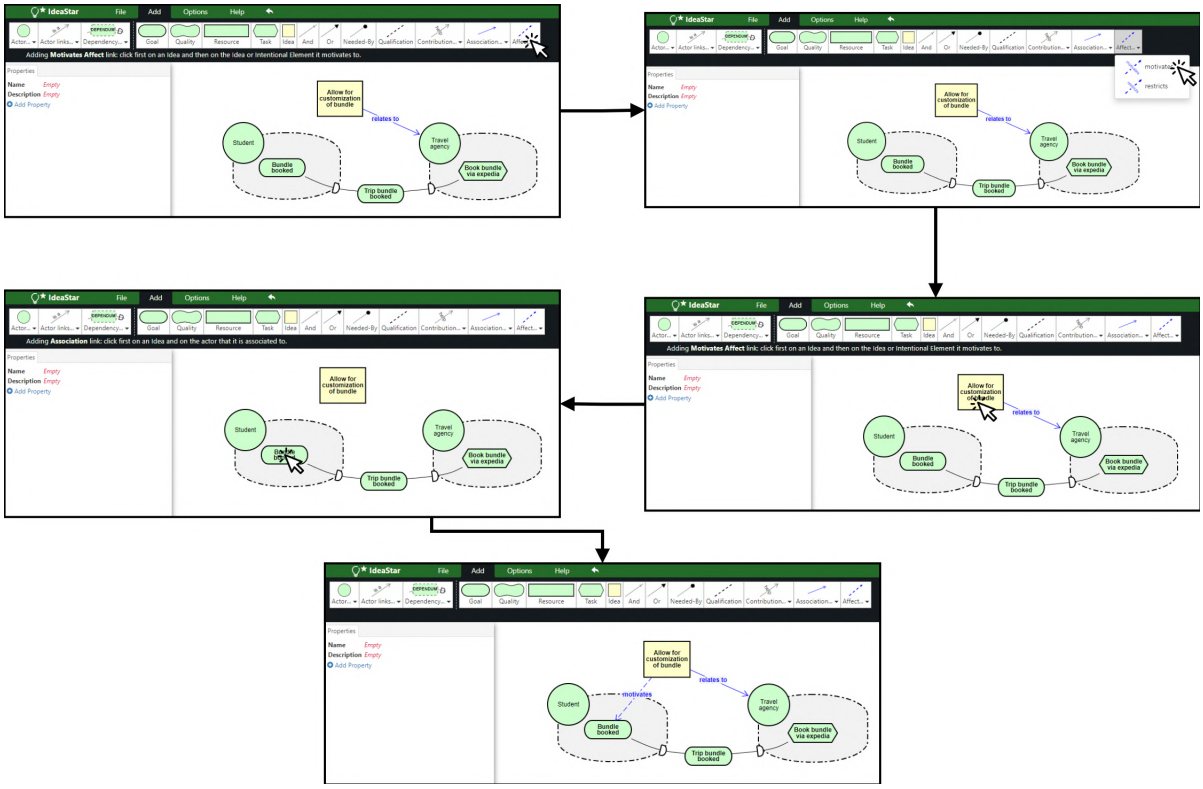


Figure 5.15: An example of adding an Affect link of type motivates

After opening the Brainstorm pop-up, the first of two tasks will appear. The user must first think about the problem they are trying to solve and what domain it is inserted into. The user is free to write anything they feel like. An error message will appear if the user tries to move on to the next task with the input box empty.

In the next task, with the previously defined problem/domain in bold, the user is free to write any idea they come up with to solve that problem or that is related to that domain. If they want to move between the two tasks, they can do so through either the "Previous" and "Next" buttons or the navigation bar. After filling the input boxes, they can save the currently written ideas and clean the input boxes using the "Add ideas to model and continue" button or save the written ideas and finish the Brainstorming session using the "Add ideas to model and exit" button. Either button will transform what's written in each input box and transforms them into Idea nodes on the model that's being currently developed. Figure 5.16 shows an example of using the Brainstorming technique. A Youtube video showing this technique's use is also available[5].

[5] https://youtu.be/nyIFlnECpdo

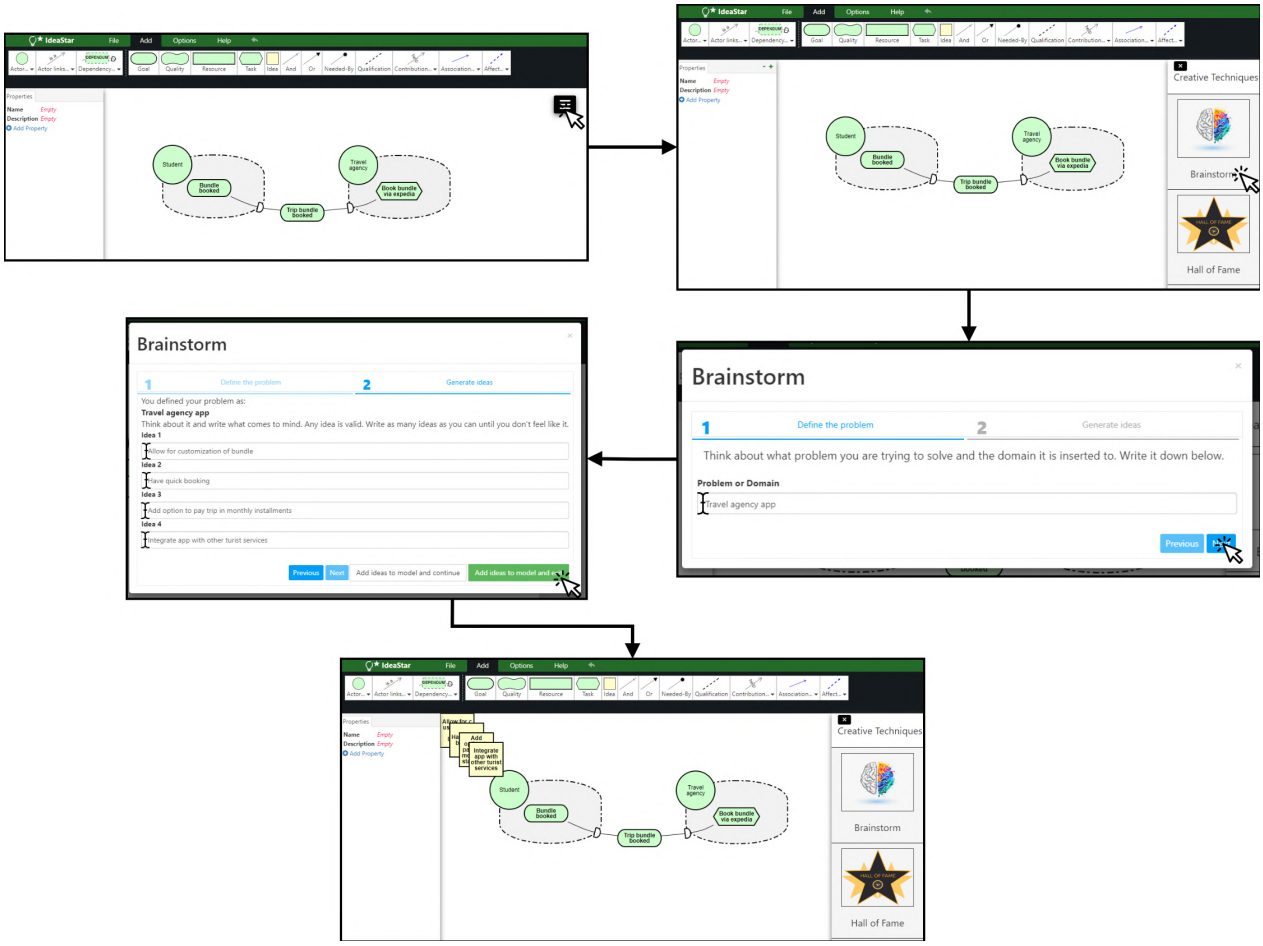


Figure 5.16: An example of using the Brainstorming technique

5.3.2 Hall of Fame

Hall of Fame is a creative technique that "*helps the participant to take a step away from the most obvious and reasonable perspectives by consulting the world's great minds*" and uses "*these characters to force connections and generate new requirements for their projects*" (Appendix A).

To use this technique, just like for Brainstorming, the user must click on the hamburger-like button on the top right side of the canvas of the diagram to open the "Creative Techniques" menu. Below Brainstorm there's the Hall of Fame option. Clicking on it will make a pop-up appear. The ND-inclusive changes and features done to the technique are the following:

- *Spark Clues*. This gives an extra source of inspiration for a guided process along the way;

- *Reduced information shown at once*. Instead of showing all of the available spark clues at once, we only show one at a time to not overwhelm the user with too much information at once.

When the Hall of Fame pop-up appears, the user is presented with a random persona, which will include a name, a category, a headline, a description, and an image. If the user desires a different persona, they can click on the "New persona" button for that effect. Under the persona, there are the Spark Clues that help the user to put into the shoes of the selected persona. They can go through each clue through the "Previous clue" and "Show next clue". Just like the Brainstorming technique the user can save the currently written ideas and clean the input boxes using the "Add ideas to model and continue" button or save the written ideas and finish the Hall of Fame session using the "Add ideas to model and exit" button. Figure 5.17 shows an example of using the Hall of Fame technique. A Youtube video showing this technique's use is also available[6].

5.4 Generate iStar elements from Idea nodes

After modeling some requirements, adding some Idea nodes either by themselves or through creative techniques, and connecting them to other iStar elements through the Association and Affect links, it is time for the final step of using our tool, transforming the Idea nodes into base iStar elements (Intentional elements, dependencies, and other links). To help with this final task, IdeaStar has a feature to more easily generate iStar elements directly from an Idea node.

To use this feature, the user needs to first click on the Idea node they want to generate an iStar element. Then, on the top left corner of that Idea node, a yellow light-bulb button will be shown. Clicking on it, a pop-up will appear. This pop-up features: the selected Idea node's text in bold, an input box to insert the text for the new Star element, and a dropdown with Actor type and Intentional elements as options. After filling in the input box and selecting an option from the dropdown, the new element will be placed on the model by clicking on the "Add element to model" button. If the user chooses an Intentional element from the box, a check box will appear asking if the user wants to "Add element as dependency link", meaning the analyst is able to transform that idea into a dependency link (which can only be of the Intentional element type) by choosing this option. Having this option checked and clicking the "Add element to model" button will then require the user to choose the source and target of the dependency link.

After clicking on the previously stated button, if the input box is empty, an error message will appear. If the element to add is of type Actor, Agent, or Role, it will be placed on the left-side corner of the diagram's canvas. If an Intentional element was chosen, then it will be placed on the top-left corner of the target Actor/Agent/Role in that Idea node's Association node. This means that, if the user wants to add an Intentional element to the model, given that originally piStar only allowed for those types of elements to be inserted within an Actor's boundary, if there's no existing Association link for that Idea node, an error will appear. The generated element will have a property named "Based on idea"

[6] https://youtu.be/9OTrot_Ef6M

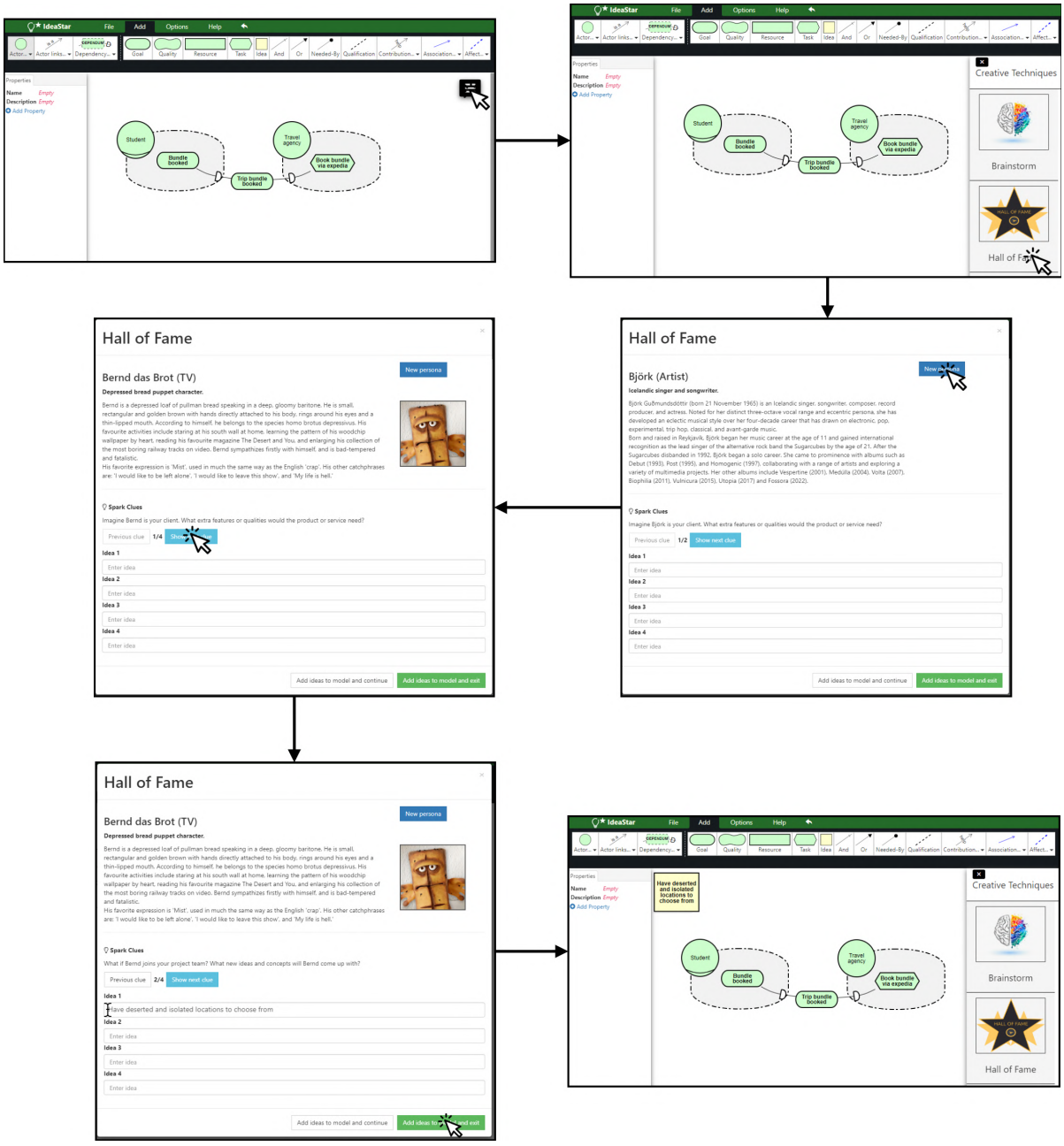


Figure 5.17: An example of using the Hall of Fame technique

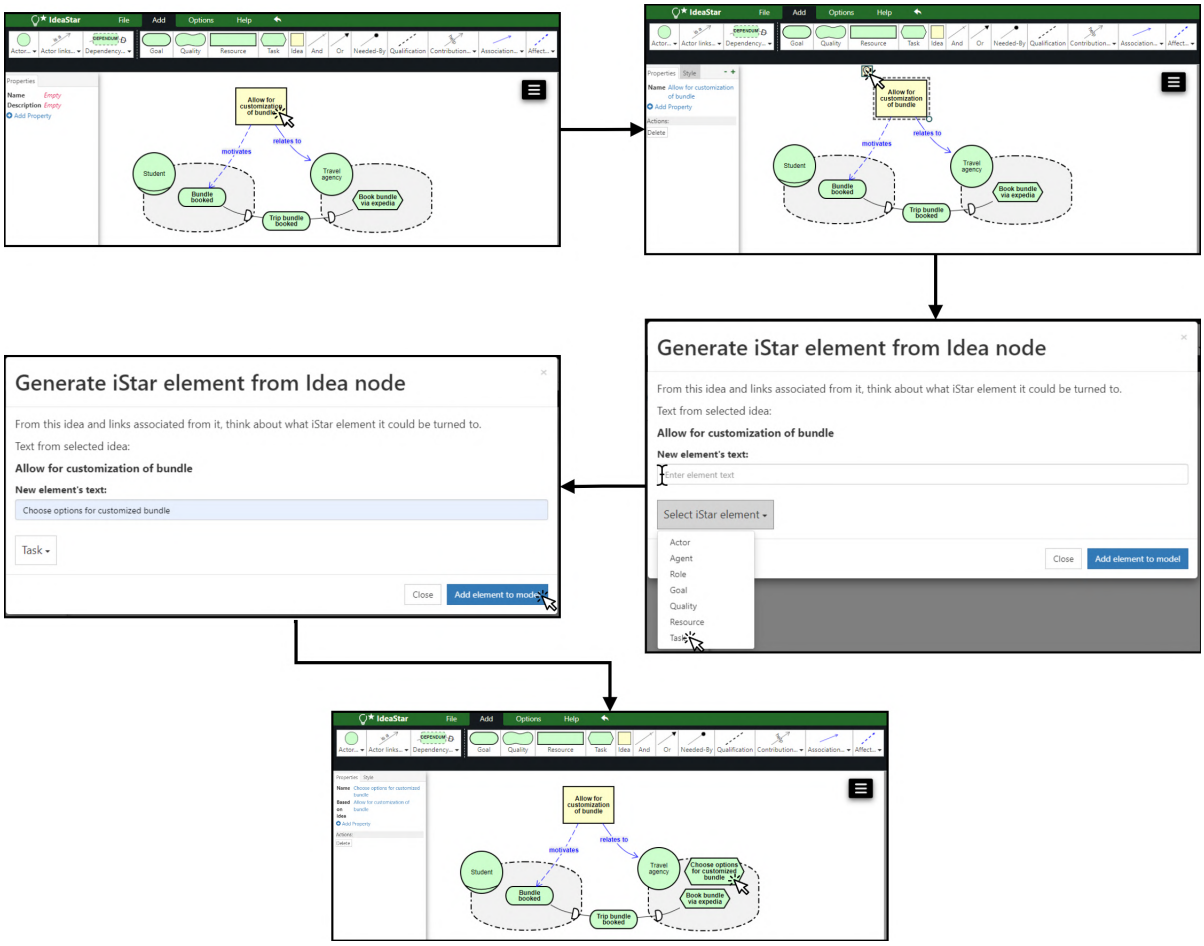


Figure 5.18: An example of generating an iStar element (Task) from an Idea node

with the same text value as the one from the Idea node it was generated from. Figure 5.18 shows an example of using this feature by adding a Task element and Figure 5.19 is an example of adding a Goal dependency link.

5.5 Summary

This chapter detailed the main functionalities of the developed neurodivergent-inclusive goal modeling tool based on the concepts from our approach detailed in Chapter 4. The tool includes the following features: accessibility options to change the font and background color of the diagram; the new iStar elements from the iStar extension; the Brainstorm and Hall of Fame creative techniques with additions to make them accessible to neurodivergent users; a generate iStar elements from Idea nodes feature that lets the user create actors, intentional elements and dependency links from idea nodes and trace the new element's origin.

Figure 5.19: An example of generating a dependency link (Goal) from an Idea node

6

Evaluation

This chapter discusses the evaluation of the developed work that formed our neurodivergent-inclusive software engineering approach. The evaluation consisted of a static validation, that is, the proposed tool was presented through a video presentation guide of our prototype of the tool to the participants who analyzed it and provided their opinions by filling in a previously prepared questionnaire. In this chapter, we begin by explaining how we created the video presentation guide and the questionnaire form, as well as how we selected our participants. Next, we present the results of our evaluation, followed by a critical discussion of those results. Finally, we address potential threats to the validity of our evaluation and conclude the chapter with our findings.

6.1 Evaluation planning

The purpose of this evaluation was to collect viewpoints, from novices and experts, about our neurodivergent-inclusive creativity based goal modeling approach. Some concepts that appear in our approach, such as neurodivergent-inclusive interfaces and the subject of applying creativity methods are still being introduced in software engineering. We also introduced a new iStar extension for creative requirements within our solution which we wanted to have feedback on. Therefore, we propose to collect perspectives on neurodivergent-inclusive interfaces, creativity in software engineering, and our iStar extension alongside the resulting tool we developed.

To achieve this goal, we created a questionnaire that collected both quantitative and qualitative data on the participant's viewpoints through an online form. The form also included a video presentation guide showing the main features of the tool. The guide must be watched to answer the questionnaire. The questionnaire collected the participants' opinions on the following measured variables for each main topic:

- Importance and benefit of neurodivergent inclusive user interfaces;
- Importance and benefit of creativity in software engineering;
- Ease of understanding and usefulness of the iStar extension for creative requirements;

- Benefit of neurodivergent inclusive creative techniques;
- Ease of understanding and usefulness of the IdeaStar tool.

In this way, we gathered a more comprehensive understanding of the opinions on the approach and its tool and the reasoning behind those perspectives.

The questionnaire was created using *Google Forms*, a free web application that allows the creation and management of online surveys. In addition, the information collected through the survey is automatically entered into a spreadsheet. The video was put on *Youtube* and the links were shared in the last section of our form. In the following subsections, we detail the created form and guide.

6.1.1 Questionnaire

The questionnaire[1] included both quantitative, multiple choice, qualitative, and open-ended questions. It was grouped into 13 sections: the introduction; a pre-survey to collect information on the participants' profiles; two versions of a section regarding neurodivergent-inclusive user interfaces (one targeted at neurotypicals and other for neuro-atypicals; depending on the answers provided in the pre-survey); two versions of a section about creativity in software engineering (again, for the same reason as the two previous sections); another profile section to know the participant's experience in goal-modeling, specifically in iStar, or lack thereof; a section about neurodivergent-inclusive creative techniques (which appears if the participant has no experience in goal modeling); a section about the IdeaStar tool. Figure 6.1 shows a flowchart of the different paths a participant may take depending on their answers on the profile sections of the questionnaire.

The information and questions were written in English, however, the participants were free to answer in English or Portuguese. A PDF version of the questionnaire is shown in Appendix B. Next, we detail each section of the questionnaire.

Introduction

This section introduces the context and the objectives of the evaluation questionnaire. It details the main targets of the survey and informs the participant that the answers are anonymous. Finally, it presents the maximum time it will take to complete the questionnaire.

Pre-survey

This section collected personal information of the participant regarding their age, gender, level of academic training, and current occupation. Finally, we also ask if the participant has been diagnosed or self-diagnosed with a neurodivergent condition. If the answer is yes we ask them to specify their condition.

[1]The questionnaire form is available in the following link: https://forms.gle/6G9d5nxsPhFXVPph7

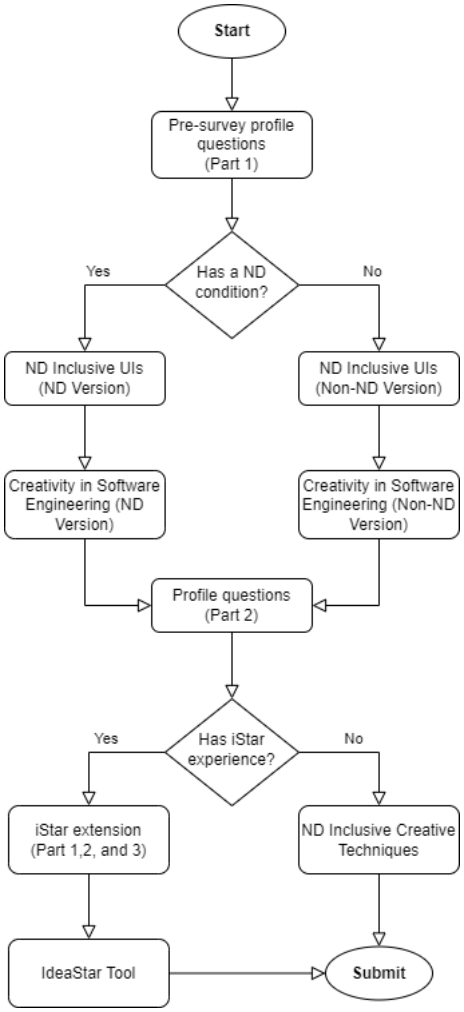


Figure 6.1: Flow chart of the different possible paths of the questionnaire

Neurodivergent Inclusive User Interfaces (UIs)

This section assessed the participants' opinions regarding inclusive interfaces, and specifically for those with a neurodivergent condition, during the development of engineering tools[2]. It included the following questions:

- A question regarding the importance of offering accessible UIs for different kinds of individuals when developing engineering tools, with 6 options ranging from 1 to 5 where 1 is not important and 5 is very important, and a 'Don't know' option;

- A question with three statements regarding the topic of addressing accessible UI issues in the software development of engineering tools for participants to rate their agreement on them on a scale from 1 to 5, 1 being strongly disagree and 5 being strongly agree with a sixth option being 'Don't know'. The statements

[2]We define engineering tools as tools/methods/practices to be used in engineering.

were "Accessibility issues are an afterthought in the development of engineering tools", "Accessibility issues should be thought out as early as possible during the development of engineering tools" and "The benefits obtained by making tools accessible do not warrant the costs".

- A question about how much effort does the participant put into adding accessibility features when developing software of any kind on a scale from 1 to 5, 1 being no effort and 5 being a lot of effort with a sixth option being 'Don't know'. This question is exclusive for those who didn't mention having a neurodivergent condition.

These questions help us understand the overall participants' opinion on how important offering accessible UIs in software development is compared to the effort they put related to that subject when developing their own software. This enables us to gather a more complete set of information and make a richer analysis of the participants' opinions.

If the participant responded that they have a neurodivergent condition in the pre-survey section, then, along with the previous questions, they would also have the following:

- A question regarding if a set of features in an engineering tool would let them do their work more efficiently for the participants to answer on a scale from 1 to 5, 1 being not beneficial at all and 5 being very beneficial with a sixth option being 'Don't know'.

- A open-ended question for the participant to write any other accessibility feature(s) that the participant feels should be present in an engineering tool that would make their job easier.

- Finally, a question about how affected the participant is by the lack of accessibility features when using engineering tools on a scale of 1 to 5, 1 being not affected at all and 5 being very affected with a sixth option being 'Don't know'.

These questions allow us to understand how particularly neurodivergent engineers are affected during their work by the lack of accessible user interfaces when using engineering tools, a piece of information that was quite scarce during our systematic review.

Creativity In Software Engineering

This section collected the participants' opinions related to the use of creativity and creative techniques in software development. It included the following questions:

- A question regarding the importance of creativity during software development, with 6 options ranging from 1 to 5 where 1 is not important and 5 is very important, and a 'Don't know' option;

- A question with four statements regarding the topic of creativity in software development for participants to rate their agreement on them on a scale from 1 to 5, 1 being

strongly disagree and 5 being strongly agree with a sixth option being 'Don't know'. The statements were "Creativity is often frowned upon in most work environments in favor of productivity and time constraints", "Creativity can only be incentivized up to a certain point, as other matters may take priority", and "Creativity is a no issue since development is already taking place in environments that facilitate novelty and curiosity, and thus creativity in software development projects" and "Creativity does not play an important role in software engineering projects".

These questions help us understand the overall participants' opinion on how important and viable it is to use creativity methods during software development.

If the participant responded that they have a neurodivergent condition in the pre-survey section, then, along with the previous questions, they would also have the following:

- A yes or no question asking if adding creativity techniques to engineering tools would be aligned with their way of thinking.
- A follow-up multiple choice question about which of the presented statements would represent a benefit of adding creativity techniques with an open-ended option. The statements were "Having a space that allows me to be creative would make my voice heard", "Using creative techniques allows me to present ideas that might be different from the norm, adding a novel quality to them." and "If the problem being solved aligns with my interests, it would allow me to use my extensive knowledge to solve said problem".

These questions serve to help us confirm if, as we found in our systematic review, creativity and neurodivergence align together.

Profile (Part 2)
This section collects information about the participants' profiles and features a single question. This question asks about the participants' experience with goal modeling, specifically with the iStar language. Depending on the answer, the participant will be sent to a different section.

Neurodivergent (ND) Inclusive Creative Techniques
If the participant answered in the profile part 2 section that they didn't have any previous experience with goal modeling, they will land on this section. This section is about the two creative techniques implemented within IdeaStar, Brainstorm, and Hall of Fame, as well as the changes that were made to those techniques to make their use more accessible to ND. This section does not make any references to goal modeling, meaning that even those without any experience in iStar can still provide feedback on our proposals for neurodivergent-inclusive creative techniques.

For each creative technique, we give a brief description of the technique, the changes we made to make it accessible to neurodivergent individuals, and an image showing the

use of the technique with screenshots from IdeaStar with any mentions of goal-modeling taken out. As for the questions, for each technique we ask about how beneficial the changes are to ND on a scale from 1 to 5, 1 being not beneficial and 5 being very beneficial and, through an open-ended question, ask for any suggestions to make that technique more accessible to ND.

This is the final section of the questionnaire for this possible path.

iStar Extension For Creative Requirements

Those who answered that they had any amount of experience with goal modeling would go to this section. This section presents the iStar extension that we developed to integrate the use of creative techniques with requirements engineering. It describes how to use the extension step-by-step and presents an image of the extension's metamodel with the three new additions highlighted.

iStar Extension Part 1. Idea node

This section presents the new Idea node added with our extension in more detail, showing the respective notation and a brief description. Then it presents one multiple choice question of 'Yes' or 'No' that asks if the Idea node can help bridge the use of creative techniques and generate new iStar elements for the model. Then, it presents one open-ended question that requests the participant to further explain their choice if they selected 'No' in the previous question. This allowed for a more comprehensive notion of the participant's opinion on what they think about the addition of an Idea node to iStar in terms of usefulness.

iStar Extension Part 2. Association and Affect Links

This section presents the new Association and Affect type links added with our extension in more detail, showing the respective notation and a brief description for each link. Then it presents one multiple-choice question of 'Yes' or 'No' that asks if the added links are enough to reflect the possible relationships between Idea nodes and other iStar elements in a model. Once again, like in the previous section, it then presents one open-ended question that requests the participant to further explain their choice if they selected 'No' in the previous question.

iStar Extension Part 3. Overall Opinion of the iStar extension

After the evaluation of each component introduced from the extension, we aimed to assess the usefulness and difficulty of understanding the overall extension. Furthermore, we aimed to collect the participants' opinions on the positive and negative aspects of the extension.

Therefore, we created a section that presents the metamodel of the extension once again and asks their overall opinion on it. It has two questions, one about the usefulness of the extension to create new and original requirements and the other about the difficulty of using it. Both provide a scale of options, from 1 to 5 where 1 is not useful and not difficult

and 5 is very useful and very difficult respectively. Then, it asks participants about the strongest and weakest points of the extension with one open-field question for each.

IdeaStar Tool

The final section of the questionnaire is meant to gather opinions on the developed prototype that implements all of the concepts discussed in the previous sections of the survey up to that point. It initially describes what the tool is and shares links for both the source code of IdeaStar, our tool, and piStar, the tool it is based on.

Then, we have four subsections for each new feature from IdeaStar that differentiates it from piStar, each with a video demonstration of said feature and some follow-up questions. Below we describe each subsection.

- *Introduction*, the video shows how to place the new components added to the iStar language from our extension on the tool's diagram. There's one question about how easy it was to understand the use of the added elements to iStar in the tool on a scale from 1 to 5, 1 being not easy at all and 5 being very easy.

- *Options*, the video shows how to use the added accessibility options that change the look of the diagram's background color and font. There are three follow-up questions. The first is about how easy it was to understand how to use the accessibility features in the tool on a scale from 1 to 5, 1 being not easy at all and 5 being very easy. The second is about how beneficial are these features on a scale from 1 to 5, 1 being not beneficial and 5 being very beneficial. The third is an open-field question asking for suggestions for more accessibility features that could be added.

- *Brainstorming*, the video shows how to use the Brainstorming creative technique in IdeaStar. There are three follow-up questions. The first is about how easy it was to understand how to use the Brainstorming technique to elicit ideas on a scale from 1 to 5, 1 being not easy at all and 5 being very easy. The second is about how beneficial the added accessibility features are to this technique on a scale from 1 to 5, 1 being not beneficial and 5 being very beneficial. The third is an open-field question asking for suggestions to make the Brainstorming technique more accessible within the tool.

- *Hall of Fame*, the video shows how to use the Hall of Fame creative technique in IdeaStar. There are three follow-up questions. The first is about how easy it was to understand how to use the Hall of Fame technique to elicit ideas on a scale from 1 to 5, 1 being not easy at all and 5 being very easy. The second is about how beneficial the added accessibility features are to this technique on a scale from 1 to 5, 1 being not beneficial and 5 being very beneficial. The third is an open-field question asking for suggestions to make the Hall of Fame technique more accessible within the tool.

6.1.2 Prototype Video Guide

To introduce the implementation of our neurodivergent-inclusive approach into an interactive tool to the participants, we created a step-by-step video guide[3], complete with a voice-over and subtitles, so every type of user can use and understand the tool. The guide has a total of 4 videos with a duration ranging from about 1 minute to 2 and a half minutes and are spoken in English with subtitles also in English. The videos are placed individually in the last section of the questionnaire and must be watched before answering the follow-up questions.

6.2 Participants selection

To evaluate the IdeaStar tool, we considered our main target as professionals in software engineering or computer science who fit any of the following criteria:

- Are familiar with goal modeling and the iStar language but **do not have** a ND condition (ASD, ADHD or Dyslexia);
- Have some ND condition (ASD, ADHD or Dyslexia) **and are not** knowledgeable in Goal Modeling or iStar;
- Have some ND condition **and are** knowledgeable in Goal Modeling or iStar.

Although our main target of interest would be neurodivergent Software engineers who know about goal modeling, we are aware that only catering to a group of that profile for our questionnaire would be quite niche and hard to find especially in an academic environment. For that reason, we decided to expand our target group to those who neither are ND nor know about goal modeling. Our questionnaire takes the profile questions into account and sends participants to different sections based on their expected knowledge on a certain topic. This way, we were able to get more responses than we initially expected and were also able to compare the ND perspective versus the non-ND one.

We gathered contacts from our own network along with bibliography authors who have expertise in goal modeling, neurodiversity, and software engineering and wrote them into a spreadsheet. Then, we used Gmail's mail merge to send an email to inquire about their participation in the study. We sent an email to each person with an introductory formal text, a brief justification for why the person was receiving this email, and the invitation to participate in the evaluation followed by the link to the form.

We shared a link to the survey through social media platforms such as *X* (formerly known as *Twitter*) and *LinkedIn*. Finally, we also used a platform called *Survey Circle* that lets users register their own surveys which are then shared with other users on the site, helping to raise the number of participants.

[3]A playlist with all 4 videos are available to view in this link: https://youtube.com/playlist?list=PLeABy4qfv6CHmcgPjyMAFE_lRUlQiQlr1&si=C_1CtRKEUcY67kYT

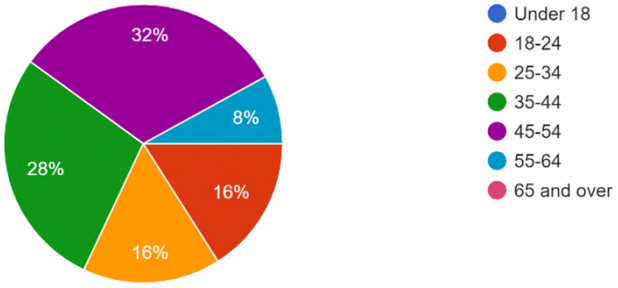


Figure 6.2: Percentage of participants by age

6.3 Results and discussion

We approach the discussion of the results in a top-down manner by following the structure of the questionnaire. Firstly, we present and discuss the general outcomes for each question. Secondly, we delve into more specific details by including the qualitative responses from the participants to complement and enhance the quantitative analysis.

The responses to the form were collected within a period of 35 days. In the end, we had a total of 25 submitted responses, all of them with training, and at least some experience, in the area of computer science, as we are going to see later in this chapter.

6.3.1 Participants demographic

These questions provided information about the characteristics of our respondents. Particularly the participants' age, gender, current occupation, academic training, and neurodivergent condition if they have any.

In terms of age, we have a balanced range with eight participants within 45-54 (32%), seven within 35-44 (28%), four within 25-34 (16%), four within 18-24 (16%), and two within 55-64 (8%), as shown in Figure 6.2.

When it comes to gender, the participants skewed more male, with sixteen participants (64%) compared to eight female participants (32%) and one (4%) person who preferred not to say, as shown in Figure 6.3. This imbalance is in fact expected, both because women are under-represented in computer science, and because many conditions are more common among men (i.e., Autism and ADHD).

As for academic training, a large portion of the participants, 68% (seventeen votes), had completed a PhD, 16% (four votes) a Bachelor's, then 8% (two votes) a Master's degree. As for the two participants left (4% each), one is finishing their Bachelor's degree and the other is a second-year Bachelor's student. Most special invites went to goal modeling experts, which explains the majority of participants having a PhD. This is shown in Figure 6.4.

A considerable percentage of our participants' main occupation is being an academic/university lecturer, that is twelve of them (48%). Then, five of them (20%) are

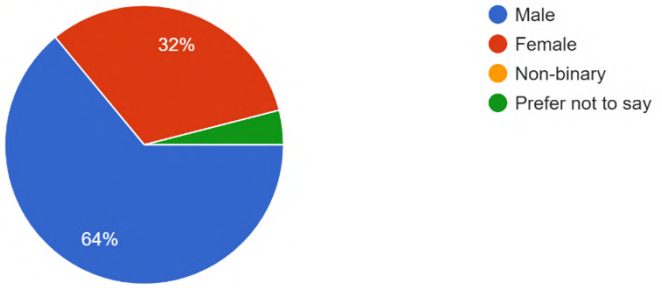


Figure 6.3: Percentage of participants by gender

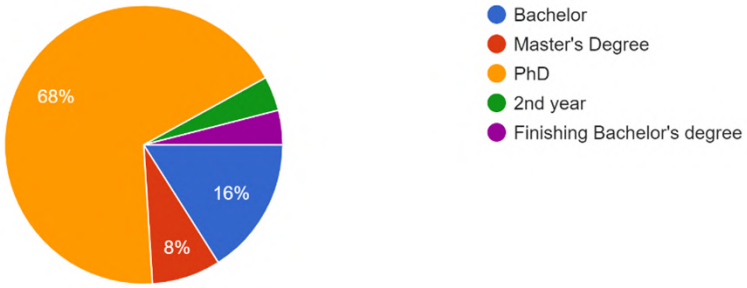


Figure 6.4: Percentage of participants by academic training

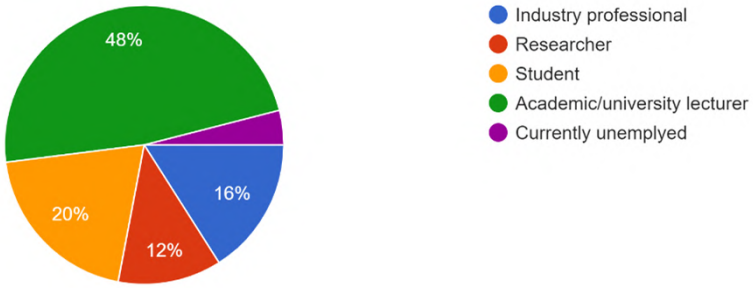


Figure 6.5: Percentage of participants by main occupation

students, followed by four industry professionals, three (12%) researchers, and finally, one (4%) unemployed individual. This is shown in Figure 6.5.

Of all the participants, we found six (24%) who were diagnosed with a neurodivergent condition and two (8%) who were self-diagnosed. There is no overlap between these participants, meaning that we have in total eight neurodivergent participants. Out of these eight participants, three have ASD, four have ADHD, one has Dyslexia, and one has OCD and depression. These stats are shown in Figures 6.6 and 6.7 respectively. Note that there is some overlap between the participants and their conditions. For added clarity, to distinguish the exciting overlap of conditions within the participants, we produced Table 6.1 to detail the profile of each participant with at least one neurodivergent condition and whether they are diagnosed or self-diagnosed. Note that one of the participants said

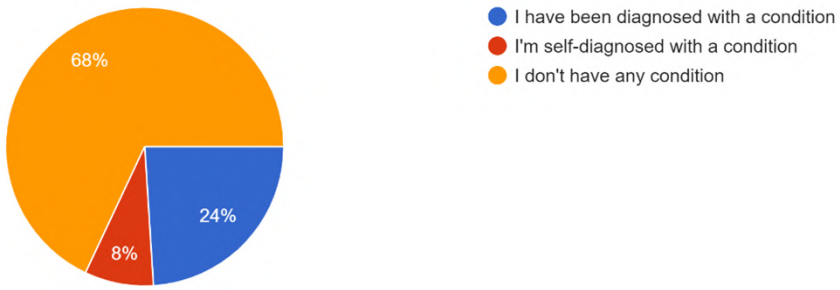


Figure 6.6: Percentage of participants by neurodiversity

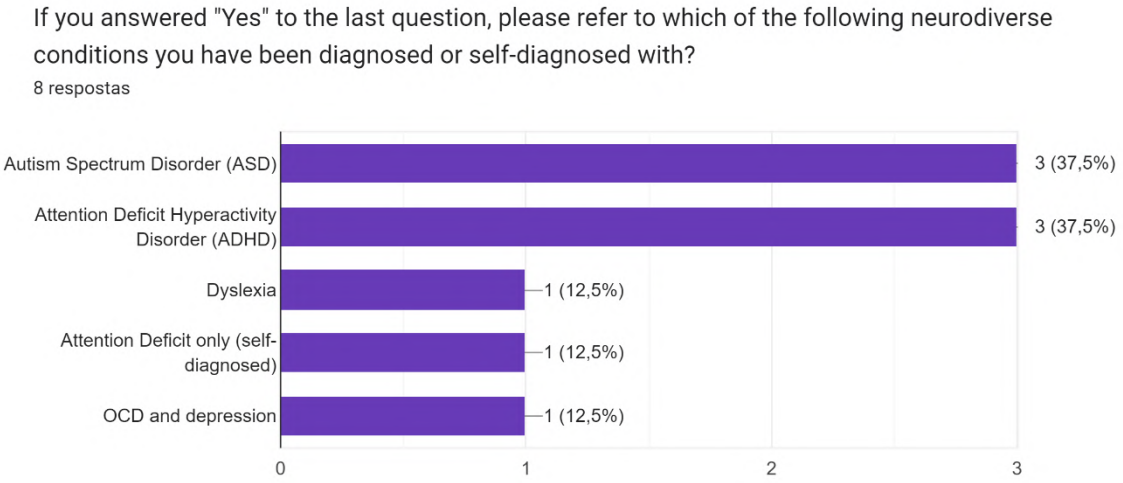


Figure 6.7: Percentage of neurodivergent participants by condition

that they are self-diagnosed with only Attention Deficit Disorder (a.k.a. ADD). However, this distinction between ADHD and ADD has been combined into just ADHD by the American Psychological Association in 1987 [43]. So, for simplicity's sake, Table 6.1 just refers to ADHD.

We acknowledge that this is not an extensive number of ND participants. However, due to the current small amount of existing information surrounding the topic of the thesis, having some amount of new perspectives and information should considered valuable, especially for an early solution to the inclusivity issues for ND in software engineering.

Regarding years of experience in goal modeling, we asked participants to select the range suitable for their level. We divided the years of experience into four groups where 1-2 years represent participants with little experience, 3-5 years we consider the participant has significant experience, and 5+ years we consider the participant an expert. We also have an option for those with no previous experience. The results are shown in Figure 6.8.

A total of 40% (ten votes) participants had more than 5 years of experience in goal modeling. One of these participants in this group is the only one of all participants to both

Participant no.	Condition					Self-diagnosed (SD) or diagnosed (D)?
	ASD	ADHD	Dyslexia	OCD	Depression	
1		X				SD
2	X	X				D
3	X					D
4		X				SD
5		X				D
6			X			D
7	X					D
8				X	X	D

Table 6.1: Neurodivergent participants profile

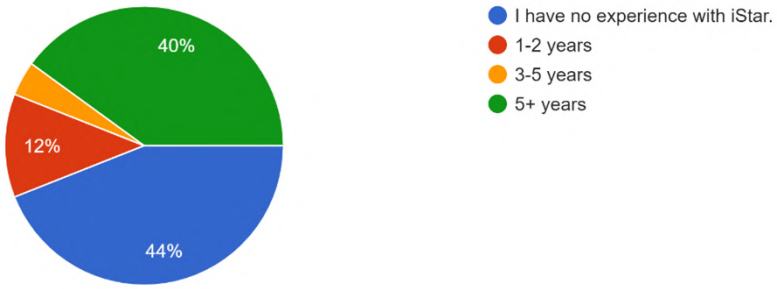


Figure 6.8: Percentage of participants by main occupation

have goal modeling experience and a neurodivergent condition, that being self-diagnosed ADHD. Continuing in the percentages of those who had some goal modeling experience, we have three votes (12%) from 1-2 years and one (1%) from 3-5 years. As for the rest of the participants, 44% (eleven votes), they do not have any experience in iStar.

6.3.2 Perceptions of neurodivergent inclusive user interfaces

The purpose of this analysis was to understand the participants' views on the importance of adding inclusive user interfaces when developing engineering tools. Being that this section had a version for ND and non-ND individuals, we were able to compare the results and understand how much effort is being done currently to address this issue and how much it actually affects ND individuals.

Therefore, we asked the participants to rate their opinion on the importance of offering accessible UIs for different kinds of individuals when developing engineering tools on a scale where '1' represents 'Not Important' and '5' represents 'Very Important' with an extra 'Don't know' option.

For Non-ND individuals, eleven consider it 'Very important', four consider it 'Important', one considers it 'Somewhat Important' and one chose the 'Don't know' option. As for ND, four consider it 'Very important', three consider it 'Important', and one 'Somewhat important'. This is shown in Figures 6.9 and 6.10.

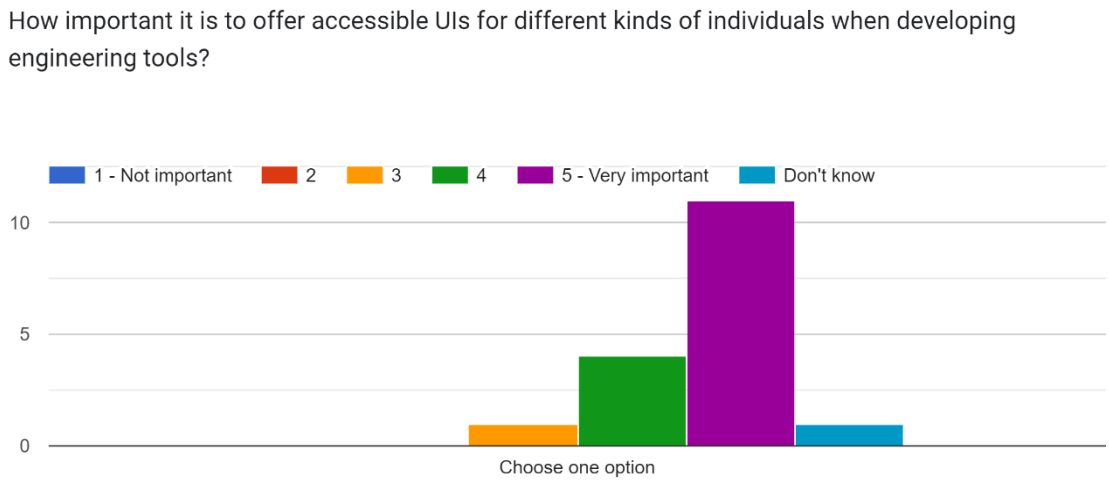


Figure 6.9: Results for the non-ND participants' opinion of the importance of offering accessible UIs for different kinds of individuals when developing engineering tools

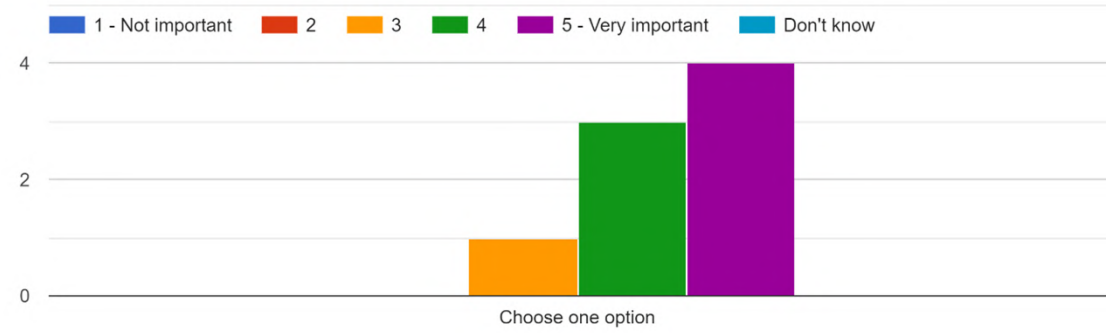


Figure 6.10: Results for the ND participants' opinion of the importance of offering accessible UIs for different kinds of individuals when developing engineering tools

With this, the results seem to demonstrate that the majority of participants consider this topic to be somewhat important in software development. Thus, it suggests the topic that the approach takes into consideration is very much relevant.

We also wanted to determine the extent to which participants were aware of issues surrounding accessible UI implementation during the development of engineering tools. To do this we asked them to rate their agreement on three different statements about this topic, with '1' being 'Strongly disagree' and 5 being 'Strongly agree' and an extra 'Don't know' option.

Non-ND participants mostly agree that "accessibility issues are an afterthought in the development of engineering tools" (eleven chose 'Agree', five 'Strongly agree' and one 'Strongly disagree') and they almost unanimously agree that "accessibility issues should be thought out as early as possible during the development of engineering tools" (thirteen choose 'Strongly agree', two 'Agree', one 'Disagree' and one 'Strongly disagree'). These results show that the majority of our participants are aware of the existing issues regarding this topic.

When it comes to if "the benefits obtained by making tools accessible do not warrant the costs", the responses are quite divided (three chose 'Strongly disagree', three 'Disagree', two neither disagree nor agree, four 'Agree', two 'Strongly agree', and three 'Don't know'). This shows that there's still debate within the Software development community about whether there's true value in addressing UI inclusivity issues that outweigh the associated (time and monetary) costs.

As for ND participants, to our surprise, two of them 'Strongly disagree' that "accessibility issues are an afterthought in the development of engineering tools" (although this could them interpreting the statement as their own opinion rather than as a reflection of the industry as we intended it to be), one neither agrees nor disagrees, three chose 'Agree', and two 'Strongly agree'. They mostly agree that "accessibility issues should be thought out as early as possible during the development of engineering tools" (five choose 'Strongly agree', one 'Agree, one neither agrees nor disagrees and one 'Disagree').

If we take our interpretation of the results for the first statement, it seems that ND participants are a bit more lenient towards the importance of addressing this issue than non-ND. Further proof of this opinion comes from the last statement of this question. Three chose 'Strongly disagree, two 'Disagree', one neither agrees nor disagrees and only one 'Strongly agree' that "the benefits obtained by making tools accessible do not warrant the costs".

Both versions of these results can be viewed in Figures 6.11 and 6.12.

The version for non-ND participants had an exclusive question for them about how much effort they put into adding accessibility features when developing software. The answers were diverse but a bit more lenient towards less effort, as six responded they give 'Little effort', then four chose 'No effort', three neither little nor much effort, three 'Some effort', and one 'A lot of effort'. This shows that there's still a lot of work to be done to bring awareness to address this issue, as shown in Figure 6.13.

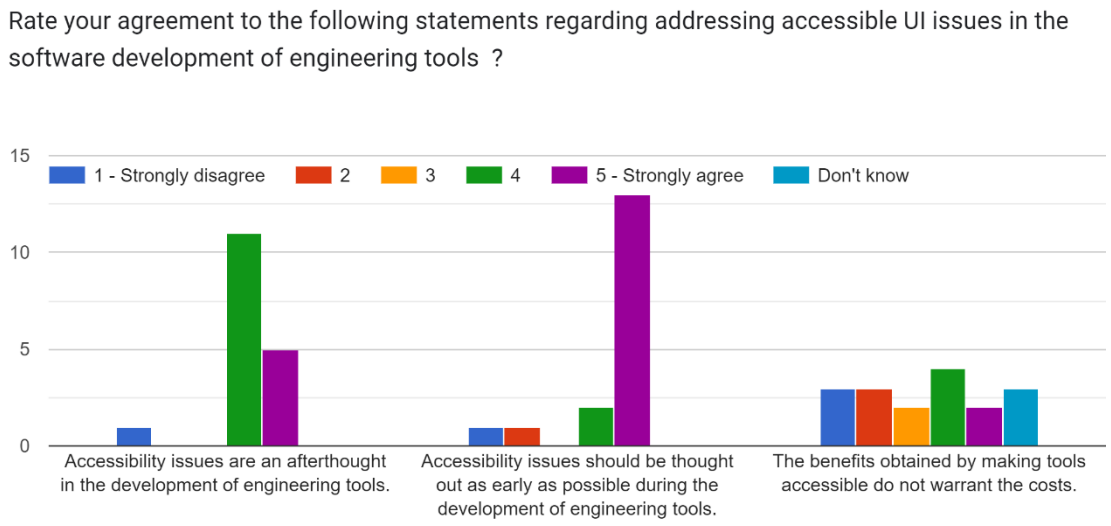


Figure 6.11: Results for the non-ND participants' opinion on issues surrounding accessible UI implementation during the development of engineering tools

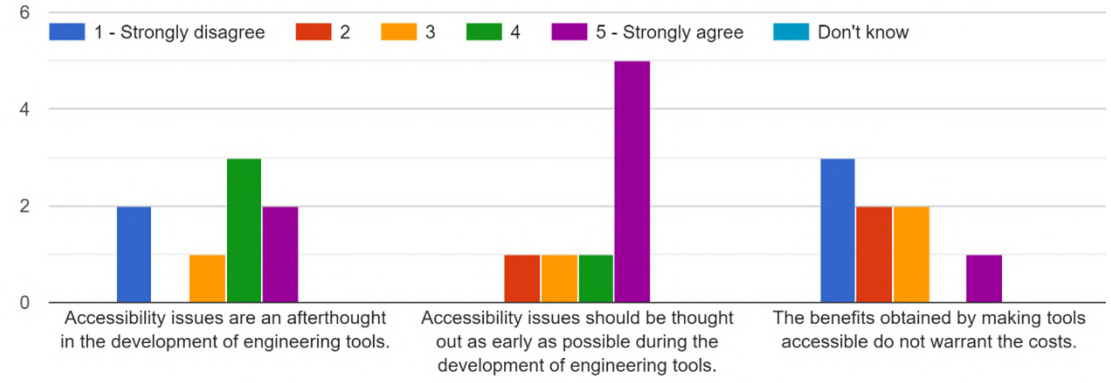


Figure 6.12: Results for the ND participants' opinion on issues surrounding accessible UI implementation during the development of engineering tools

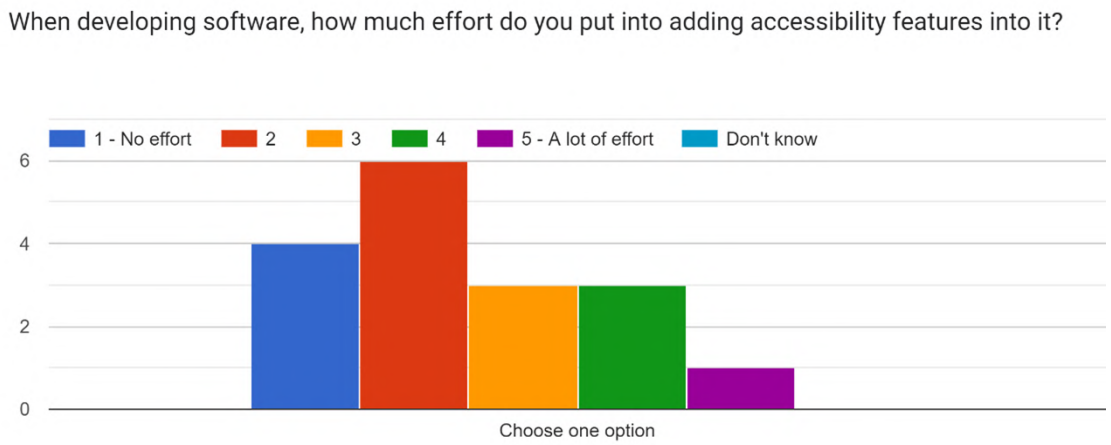


Figure 6.13: Results for the non-ND participants' effort into adding accessibility features when developing software

Comparatively, we wanted to know how affected our ND participants are by the lack of accessibility features and how beneficial they are for them when they exist.

We mentioned four accessibility features that we implemented in our tool (but without them knowing that context) and asked them to rate the level of benefit to them. The options to change the background color and to change the font were only somewhat beneficial overall and had similar results. For the first feature, one chose 'Little benefit', two 'Somewhat beneficial', three 'Beneficial', and two 'Very beneficial'. As for the second feature, the only difference was between 'Beneficial' and 'Very beneficial', who had their values swaped.

Wizard-style navigation showed a bit more promise overall, with two choosing 'Very beneficial', three 'Beneficial', one 'Somewhat beneficial', one 'Little benefit', and one 'No benefit at all'. Finally, reducing the amount of information shown at once is the most promising feature/design of all the features discussed. Our ND participants either said it was 'Somewhat beneficial'(four votes) or 'Very beneficial' (four votes).

These results are shown in Figure 6.14.

We also asked for their own suggestions of accessibility features or design choices that could benefit neurodivergent engineers. Four of our ND participants who landed on this section gave some suggestions of their own.

One of our ADHD participants referred to the importance of Nudging as a design philosophy. In the link provided in the answer it reads "*From a UX perspective, nudge refers to the use of design elements and features to influence and guide users toward a desired action or decision. It can be seen as a way of gently shaping the user experience to lead to better outcomes, without being intrusive or taking away from the user's autonomy*". This sort of philosophy is

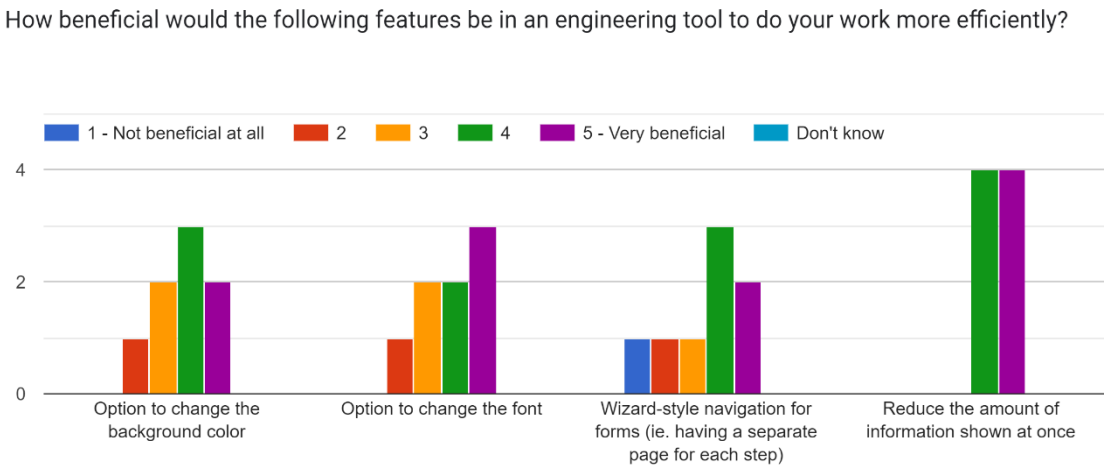


Figure 6.14: Results for the ND participants' beneficial rates for the four shown accessibility features

somewhat related to our approach, as we desired to make a tool that would make the whole goal modeling process more streamlined without taking away any complexity of the end-result model.

One respondent with ASD placed a set of guidelines that can be helpful in making accessible software. Many of them are already present in our guidelines set in Table 4.3. Some interesting guidelines that were mentioned and could complement our table are the following:

- "*Keyboard Shortcuts and Navigation: Ensure that the tool is fully navigable and operable using keyboard shortcuts, as some users may prefer keyboard-based interactions over mouse-based ones.*"
- "*User Feedback Mechanism: Implement a user feedback mechanism within the tool, so users can provide input on their experience and suggest improvements or accommodations.*"
- "*Sensitivity to Time Management: Include features to set timers, reminders, or notifications to help users with time management and task scheduling.*"
- "*Community and Peer Support: Facilitate user forums or communities where users can connect, share experiences, and offer support and advice to each other.*"

Another respondent with ASD pointed out how having the concepts well-documented helps them to use engineering tools more effectively: "There should be easily accessible documentation for engineering tools that show detailed levels of information for people like me who thrive on details and shortened versions for people who are prone to overloading on information".

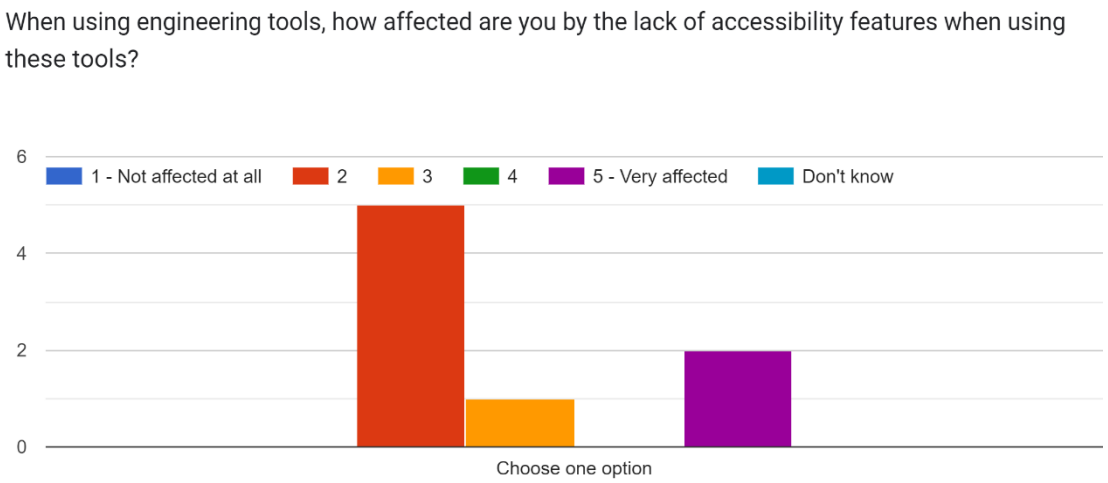


Figure 6.15: Results for the ND participants' affected rate by the lack of accessibility features in software engineering tools

Our dyslexic participant brought attention that being able to control contrast is as important as the choice of color: "Focusing on contrast rather than just the colors is important".

Finally, we asked our ND participants to rate how affected they were by the lack of accessibility features when using these tools. The results surprisingly skewed to not being as affected as we expected them to be initially. Five answered to only be a 'Little affected', one neither 'Somewhat Affected', and 2 'Very affected'. We wonder if these results are a reflection of how ND users usually just adapt to their circumstances when it comes to using software rather than being aware of possible solutions to better their usage of software. Still, the results show some struggle when accessibility features are not present, even if it is just a little. The results can be seen in Figure 6.15

6.3.3 Creativity In Software Development

Next up, we inquired our participants about their perspectives on using creative methods and techniques during software development. Once again, like in the previous section of the questionnaire, this one also had two separate versions for those with neurodivergent a condition and one for those without. Let's start with the general questions for both versions.

We first wanted participants to rate the importance of creativity in software engineering on a scale where '1' represents 'Not Important' and '5' means 'Very Important' with an extra 'Don't know' option. Both types of participants came to the same result: creativity is important in software engineering. For non-ND participants, eight responded 'Important'

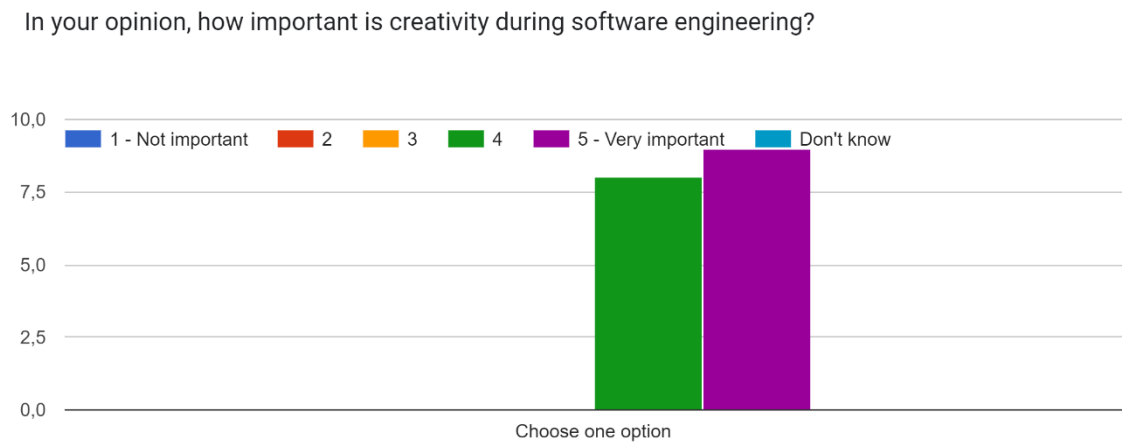


Figure 6.16: Results for the non-ND participants' opinion on the importance of creativity in Software Engineering

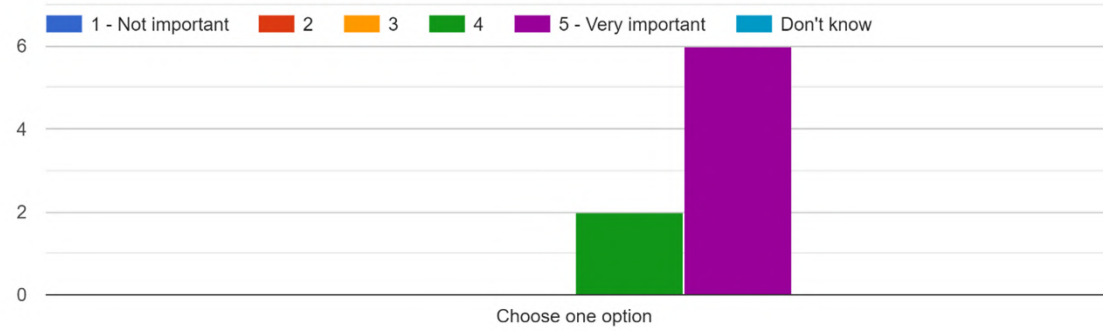


Figure 6.17: Results for the ND participants' opinion on the importance of creativity in Software Engineering

and nine 'Very important'. In the case of ND participants, two responded 'Important' and six 'Very important'. Both of these results can be seen in Figures 6.16 and 6.17.

These results show a lot of promise in our choice to do a creativity-guided approach. It gives confidence to further study more software engineering methods that implement creativity methods.

We also wanted to determine the extent to which participants were aware of issues surrounding the use of creativity during the development of engineering tools. To do this we asked them to rate their agreement on three different statements about this topic, with '1' being 'Strongly disagree' and 5 being 'Strongly agree' and an extra 'Don't know' option.

Non-ND participants lean towards agreeing that "creativity is often frowned upon

in most work environments in favor of productivity and time constraints" (eight chose 'Agree', five 'Strongly agree', three 'neither agree nor disagree', and one 'Disagree') and that "creativity can only be incentivized up to a certain point, as other matters may take priority" (ten chose 'Agree', three neither agree nor disagree, two 'Disagree', one 'Strongly disagree, and one 'Dont know'). They mostly disagree with the statement that "creativity is a no issue since development is already taking place in environments that facilitate novelty and curiosity, and thus creativity in software development projects" (ten chose 'Disagree', two 'Strongly disagree', two neither agrees nor disagree, two 'Agree', and one 'Don't know').

This consensus also carries to our ND participants. For the first statement, three chose 'Strongly agree', two 'Agree', one 'Neither agree nor disagree', and two 'Disagree'. For the second statement, we have three answers for 'Strongly agree', three for 'Agree', one for 'Disagree', and one for 'Strongly Disagree'. Finally, for the third statement, three for 'Strongly disagree', three for 'Disagree', one for 'Agree', and one 'Strongly agree'.

Our participants seem to be aware that creativity still has some roadblocks in order to be fully part of software engineering, be it because of a lack of interest or other aspects of software development taking higher priority. The results can be seen in Figures 6.18 and 6.19.

For our ND participants, we had two extra questions that gathered their perspectives on how much creativity aligns with their way of thinking and if so, in what way.

In a 'Yes' or 'No' question, the respondents all unanimously said that creativity goes along with their own distinct cognitive way of thinking, as shown in Figure 6.20. The follow-up multiple choice question asked which of the three statements shown would be the benefits of adding creativity techniques. The one that was the most selected was "if the problem being solved aligns with my interests, it would allow me to use my extensive knowledge to solve said problem" with seven votes (87.5%), followed by "Using creative techniques allows me to present ideas that might be different from the norm, adding a novel quality to them" with five votes (62.5%), and finally three votes (37.5%) for "Having a space that allows me to be creative would make my voice heard". The results are shown in Figure 6.21.

Naturally, this is too small of a sample to reach any concrete conclusions about the benefits of using creativity as an inclusive tool for ND individuals, however, it does give further proof for the information we found during our systematic review that, indeed, there might be a link between creativity and neurodivergence that could be used as a strength when applied in the right field.

6.3.4 Neurodivergent Inclusive Creative Techniques

For the participants who said they didn't have any previous experience with iStar, we took the opportunity to still get their feedback on the neurodivergent-inclusive changes we made to the Brainstorm and Hal of Fame creative techniques but without any goal modeling

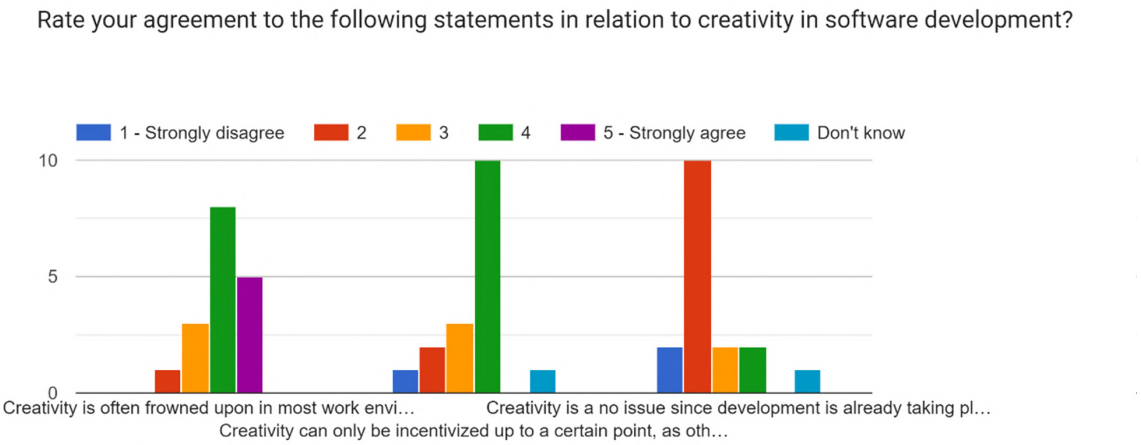


Figure 6.18: Results for the non-ND participants' opinion on issues surrounding creativity in Software Engineering

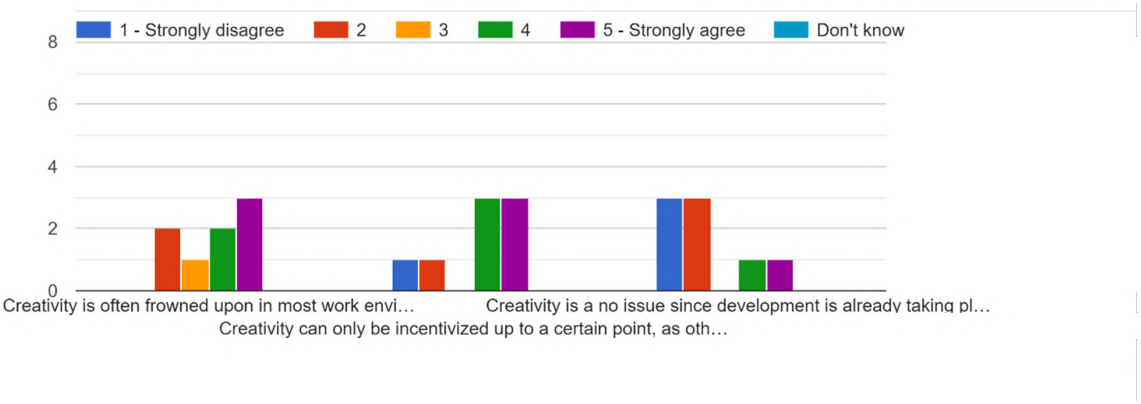


Figure 6.19: Results for the ND participants' opinion on issues surrounding creativity in Software Engineering

relation. This subsection presents the results of the evaluation of the changes/additions for each technique and suggestions given by our participants.

Brainstorm

For Brainstorm, we asked participants to rate their opinion on how beneficial it is to have Wizard-style navigation and defining a problem/domain as a starting point for this technique on scale of 1 to 5. The results are leaning towards being beneficial. 54.5% (six votes) of those who landed on this section voted 4 (four of these votes came from neurodivergent individuals), two voted 5 (both of these votes came from neurodivergent individuals), and then all other scales had one vote each, representing 9.1% of respondents for each (with the vote on 1 actually being from a neurodivergent individual). The results can be seen in

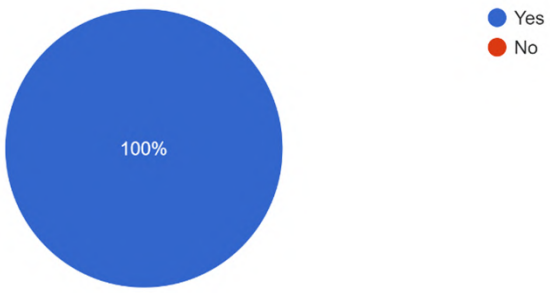


Figure 6.20: Percentage of ND participants of which their way of thinking aligns with creativity

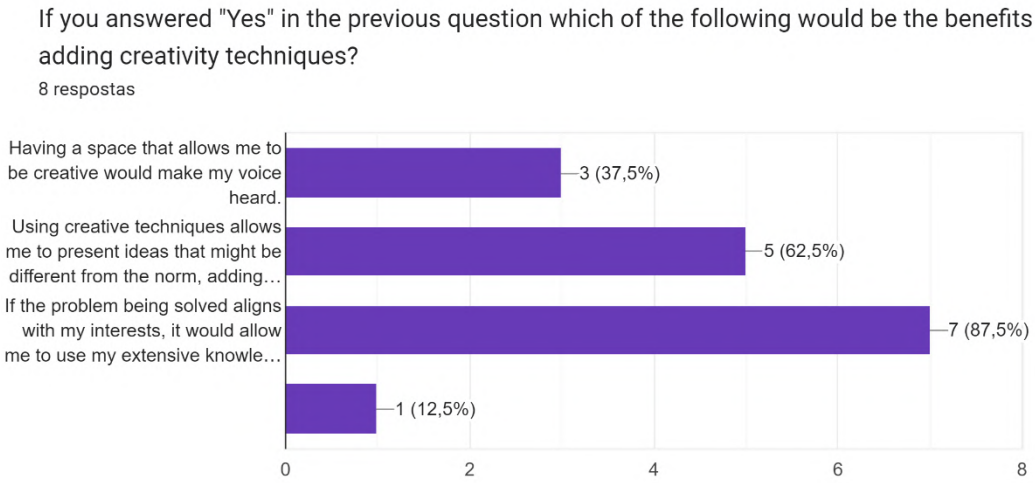


Figure 6.21: Results for the ND participants' benefit rates associated with using creativity methods

Figure 6.22.

The only participant who voted 1 and also has ADHD left the following suggestion to make this technique more accessible: "In my mind brainstorming should be open-ended in freeform. It benefits from the creation of graphs to connect ideas, possibly even freehand, or at least from being able to organize ideas hierarchically, e.g., in OneNote". This suggestion points towards possibly allowing the user to have the option to have a more liberating use of the technique and expand the documentation of ideas beyond the written text.

This possibility of ordering ideas was also left by another ND participant with ASD: "Having a second form to classify these ideas into sub-categories could be helpful if I'm more confident in one idea than the others."

Hall of Fame

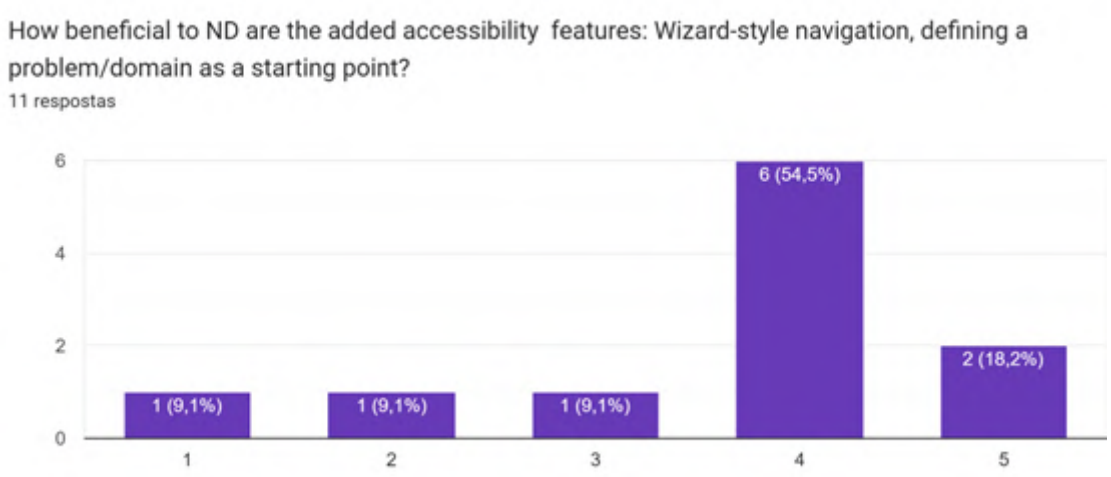


Figure 6.22: Results for the participants' beneficial rate for the additions/changes done to Brainstorm

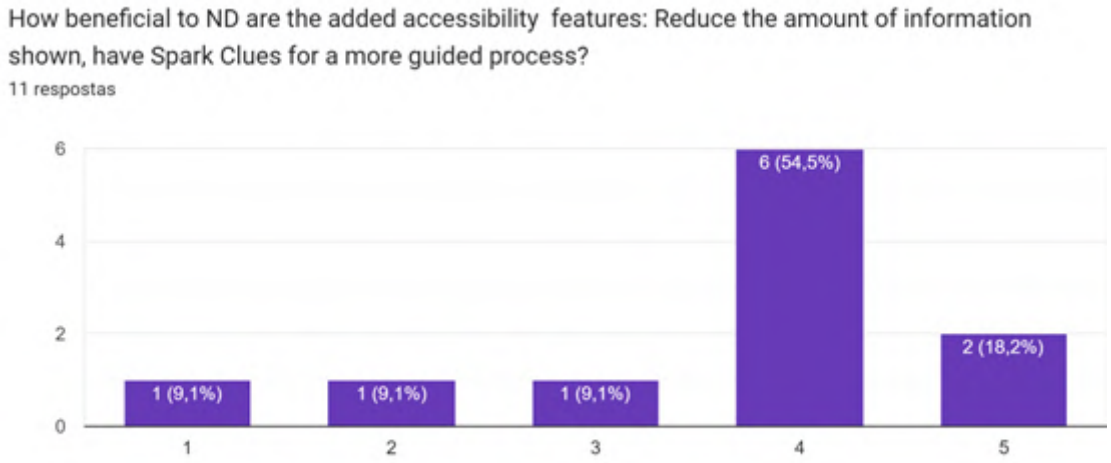


Figure 6.23: Results for the participants' beneficial rate for the additions/changes done to Brainstorm

The results for Hall of Fame, when asked to participants to rate their opinion on the added accessibility features to the technique (reduce the amount of information shown, have Spark Clues for a more guided process), mirror the ones found in the subsection for Brainstorm. The results can be seen in Figure 6.23.

Like in the Brainstorm subsection, the only vote on scale 1 was also from a neurodivergent participant (the same one who also voted 1 on the benefits question for Brainstorm).

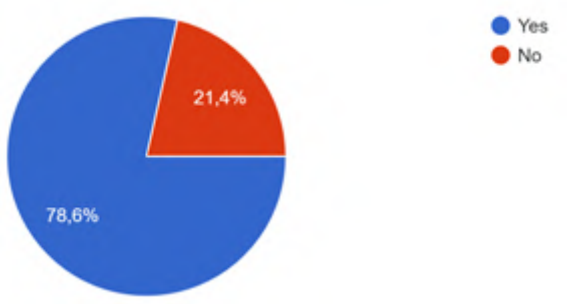


Figure 6.24: Percentage acceptance for the Idea node

In the suggestion follow-up open-ended question this participant wrote: "my type of neurodivergence benefits from frameworks for organizing ideas, but without boxing them in too much". Once again, this goes to show that there should definitively be a consideration for different types of neurodivergence, given that it finds itself on a spectrum. While in the prototype version of our tool, we focused on streamlining the goal modeling process, some might actually prefer to have a more freeform version of the techniques.

This freedom of choice is also present in the following suggestion from a participant with ASD: "Having the option of toggling between showing one clue and all clues would be good. Not all people with ND suffer from informational overload and having this option could help with increased accessibility for both sides of this specific spectrum".

The individual with OCD points out how the description text should "be separated by spaces according to the information" or alternatively a "summarised version to help understand first the big picture and then go into the details with the block of text". They clarify the reasoning behind this suggestion: "The current way makes me skip lines of text or not read it to the end, trying to answer the question and not understanding because I skipped a big portion of the text, frustrated, I go back to reading the text again a may do same behavior again in a loop until I force my self to read the block of text."

6.3.5 iStar Extension For Creative Requirements

This subsection presents the results of the iStar extension evaluation. We decided to first collect feedback for each component added to the iStar language, and then gather the overall opinion on the extension.

Idea node

The results for the Idea node element from our extension were rather positive, as shown in Figure 6.24. 78.6% (eleven votes) of the 14 participants with goal modeling experience answered 'Yes' when asked if "Idea nodes help bridge the use of creative techniques and generate new iStar elements for the model".

However, three participants (21.4%) answered 'No'. In the follow-up question, for those same participants, we asked for their own suggestions to improve this element. Two

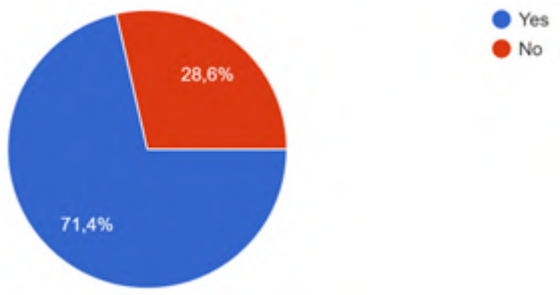


Figure 6.25: Percentage acceptance for the Association and Affect links

of those participants suggested changing the icon from a yellow square to a light bulb. One of the participants explains further: "The icon is not very intuitive. I would have used a bulb icon + a description of the idea with a more structured information. IMHO a square with a name might not be enough to bridge this gap."

While a light bulb could be an easier way to represent the concept of an "idea", as it is stereotypically personified in various forms of media [36], there are some complications we had to consider. First, a light bulb icon wouldn't be able to contain as much information as a square without having to stretch and increase the size considerably. The participant does take this into consideration by having a description associated with it. But this would require more steps to view its relevant information. The decision to use a yellow square was also based on the usage of Post-its (something we forgot but should have mentioned on the questionnaire) while keeping the tradition of the simple shapes used for elements in iStar.

The other suggestion pointed to two issues in their opinion. For one, they point out that "the fact that the language supports the specification of an idea does not mean that the development process will be creative". We do agree on this point, but we also point in the description of the extension in the survey that the extension is to be used with creativity techniques to help elicit novel requirements. Then, they also comment that they "believe that the i* model will contain so much information". This will be a recurring critique that we will explain further in the sub-section regarding the overall opinions of the extension.

Association and Affect links

The results for the Association and Affect links were also overall positive, albeit slightly more negative than the opinions on the Idea node. 71.4% of the participants were positive that the "added links enough to reflect the possible relationships between Idea nodes and other iStar elements in the model". This is shown in Figure 6.25.

The four (28.6%) participants (plus one who actually had responded 'Yes' but chose to leave some suggestions anyway) provided some motivations for their responses.

There were some comments directed at the naming conventions chosen for the links. One comment talks about how "the "motivates" link is too close to the "restricts" link", likewise, another comment reads "Is restricts the opposite of motivates, and vice versa?

Could they be two sides of the same coin?". Finally, one participant suggests using the name "Contributes to". The naming convention for the Affect type links took a lot of consideration when we were developing the extension. We wanted to use names that wouldn't be too final in their meaning, given that ideas are just concepts that could or could not be introduced definitively into the model as an iStar base element. At the same time, we wanted users to be able to consider in what way an idea **could** affect another element of the model either positively or negatively, which is why we chose to have a *motivates* link and a *restricts* links. Still, these names could be modified in the future to better serve the previously stated point.

One participant commented how "there is no "symbolic" meaning between the arrows and the semantics of what they want to represent". We have a unique color for the added links (blue) to distinguish them compared to standard iStar links. Between Association and Affect links we used a dashed line and a straight line plus their associated names to differentiate them. However, these choices only really make them different from other elements but do not have a relation to their actual meaning, unlike the Idea node which is based on a post-it (making it an association with a real-life object). This suggestion leads us to revalue the chosen notation for the links in the future to make them clearer as to what they should represent.

Finally, we have an interesting suggestion for an extra type of link. The suggestion reads: "It would be great to have an arrow to indicate neutral or unknown relationships. An idea may affect an actor or a goal, but neither motivates nor constrains them". This could definitively be a valuable type of link to use whenever the user *knows* that the idea will affect an element but does not know for sure *how*.

Overall Opinion of the iStar extension

After evaluating the new iStar components added by the extension, we asked participants about their overall opinions about the extension. First, we asked participants to rate the usefulness of the extension to create new and original requirements on a scale from 1 to 5 where one is "Not useful" and five is "Very useful". Then, we asked participants how difficult it is to understand the extension with the same format as the previous question, but 1 represents "Not Difficult" and 5 is "Very Difficult".

These are two essential traits for the extension. To make it useful, it must be both clear and precise. It should be easy for users to understand and apply, while also covering all the relevant concepts to be considered reliable and useful for achieving its intended tasks.

To conclude this section of the questionnaire, we asked participants to share their opinions on the strengths and weaknesses of the model.

Usefulness to create new and original requirements

As we can see in Figure 6.26, the results lean towards being 'Somewhat useful' and 'Useful', suggesting that there's definitively some potential to be found in the extension, although it requires some work to get at a higher level of usefulness. Six (42.9%) participants

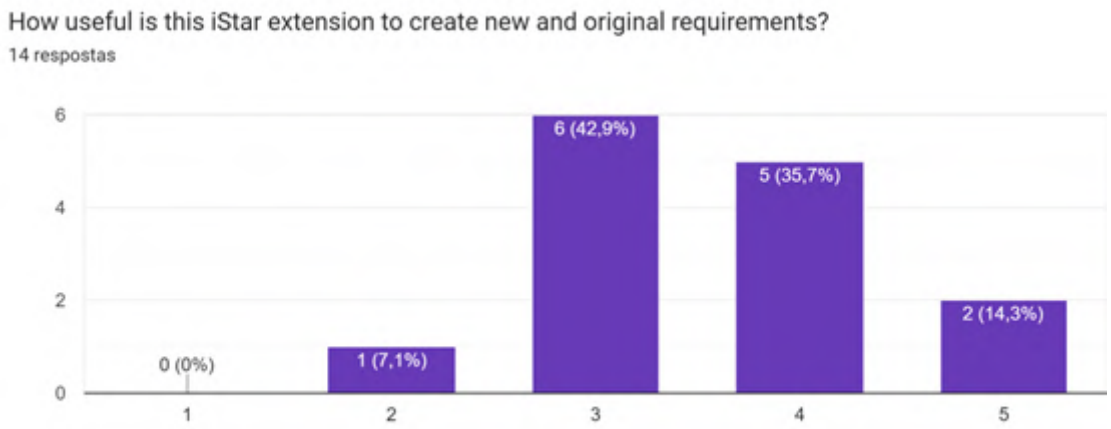


Figure 6.26: Results for the participants' opinions on the usefulness of the extension

considered it to be 'Somewhat useful'. When we consider only answers higher than 3, we have 50% of participants, 53.7% (four votes) for 'Useful' and 14.3% (two votes) for 'Very useful'. Only one participant (7.1%) voted 'Slightly useful'.

Difficulty in understanding the extension

The results for the difficulty of understanding the extension are overall on the easier side as shown in Figure 6.27. These results indicate that we have successfully made an extension where the added components are easily understandable in their usage which could make them easier to apply in a professional scenario. Nine (64,3%) participants consider it Not difficult to understand the extension, followed by three votes for 'Somewhat difficult', and one (7.1%) vote for 'Slightly difficult' and one for 'Difficult'.

Overall, we believe that our aim of balancing the extension in order for it to be both useful and understandable was moderately achieved. Some changes might be beneficial in order to make the extension more appropriate to use alongside creative techniques.

Strongest points of the extension

Out of the fourteen participants who had previous iStar experience, eleven (78.6%) provided their opinions on the strongest points of the extension. Thus, the extension is likely to generate interest among the majority of participants, warranting further analysis.

One of the most praised aspects of the extension is the existence of the Idea node, and how it expands the possibilities for representations of additional and novel concepts. The following comments stood out to us:

- "Increase the traceability of creativity techniques to the goals"

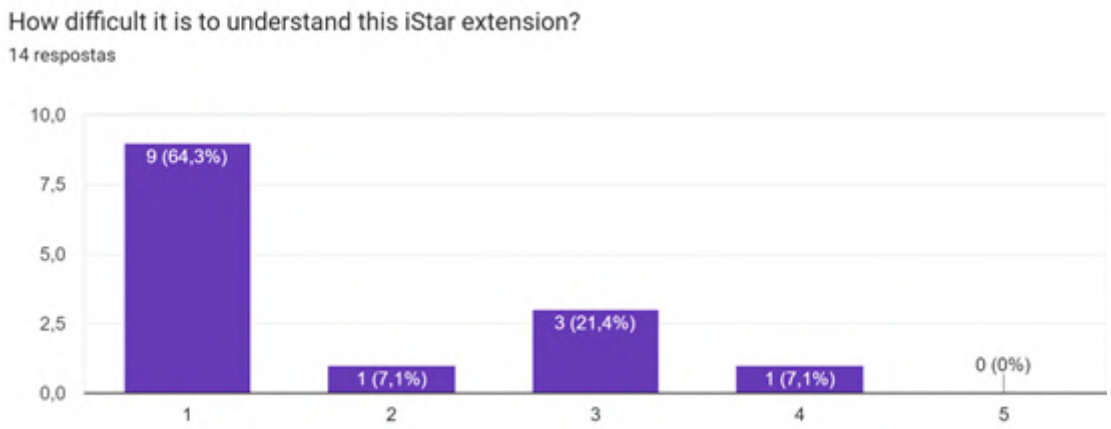


Figure 6.27: Results for the participants' opinions on the difficulty of use of the extension

- "It allows a modeller to explicitly represent the corresponding information in the diagrams"
- "I find interesting to have an expresivity related to creativity ideas"
- "Idea is a core element of the modeling notation, so innovation becomes clear"
- "The possibility of associating the idea to actors and tasks"
- "Integration of vague ideas related to the actual model"

We also had many comments addressing the overall conceptualization of the extension:

- "Easy and flexible"
- "the concepts are useful"
- "The new elements are streamlined and well placed in the model" (translated from Portuguese)

These comments point towards the ease of use and usefulness we desired for the extension.

Overall, the feedback is encouraging and provides valuable information on how diverse participants perceived the extension.

Weakest points of the extension

Regarding the extension's weakest points, the responses could be divided into two groups: The first group focused on the added complexity of models the extension would bring to an already complex language.

- "I believe that the i* model will contain so much information. Imagine a scenario that every NFR [Non-Functional-Requirement] has an extension associated and [how] difficult to understand and maintain will be"
- "Its use might result in larger models (more difficult to understand, manage...)"
- "(...) One of the drawbacks for the iStar notation use to be the complexity for medium or large systems, and this technique makes the notation more complex"
- "Other elements that easily increase the complexity of the diagrams"

These comments point towards a deeper problem within the iStar language itself, that being its tendency to produce large and complex models that make it difficult to manage and understand outside of those who developed it. These scalability problems have been mentioned many times within the Software Engineering community [47]. It's a setback that we could only work around to limit the issue given the nature of the language. It is something that our tool in the future could help remedy with certain new features. One example could be to simplify the visible information related to certain Idea nodes that would not be worked on at that moment, making the overall model less cluttered to work on.

The second group mentioned how the concept of an idea can be quite abstract and hard to ground in a palpable way:

- "Idea is a very abstract concept that can be hard to manage."
- "Ideas are so abstract that maybe some of them cannot be instantiated easily"

Indeed, an idea is a very broad concept to conceptualize. Yet, that same liberty can be used to represent ideas that have not been fully realized at one point, giving more freedom and less pressure to modelers to find an exact solution right away. In our extension, the idea should be seen as a means (documenting possible new requirements and tracing their origin) to an end (new iStar elements and/or links).

We also got a comment regarding "the graphical notation" by the same participant who talked about it in the subsubsection 6.3.5 where we already detailed our thoughts on such a comment.

6.3.6 IdeaStar tool evaluation

This subsection presents the results of the IdeaStar tool evaluation. We decided to collect individual feedback for each new feature we added from piStar. Expect the first video showcasing the use of the iStar extension within the tool (as we already evaluated in previous sections), for each feature we asked participants to rate on a scale from 1 to 5 how easy it was to understand the use of said feature (from the presented video guide) and how beneficial to ND they believe it to be. Then, we ask for suggestions for other features that could help make said part of the tool more accessible to ND. For this section,

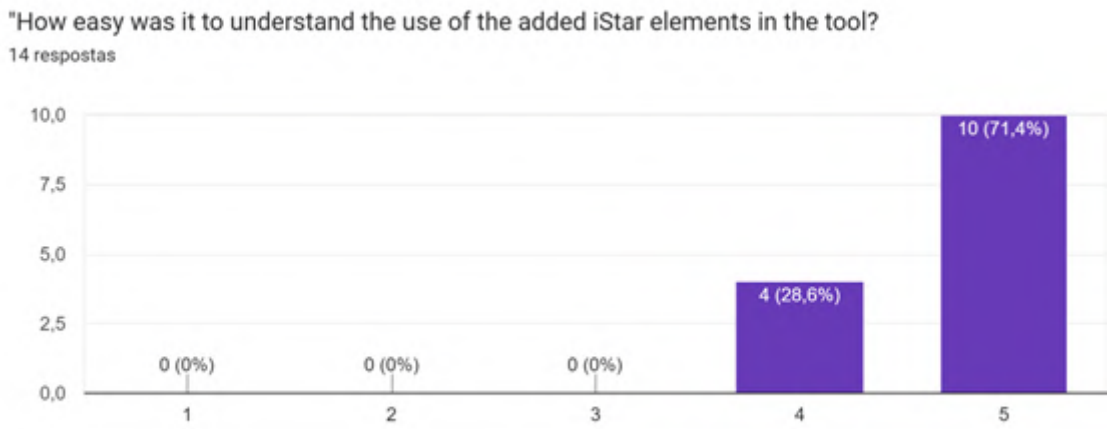


Figure 6.28: Results for the participants' opinion on the difficulty in using the iStar extension in the tool

we got one participant who had some experience in goal modeling (more than 5 years) with a self-diagnosed ADHD condition.

iStar extension use within IdeaStar

The first question, regarding how easy it was to understand the use of the added iStar elements in the tool, was quite positive. As shown in Figure 6.28 ten (71.4%) participants voted 5 and four (28.6%) voted 4. These results should be directed towards the developers of piStar, the tool IdeaStar is based on, given that it was made to easily support the addition of iStar extensions into the tool. Still, given the importance of the extension to our approach, it is promising to see that participants had no difficulty understanding how to use the extension within the tool.

Accessibility options

Next, we asked for the participants' opinions about the added accessibility option in the tool. These features refer to the ability to change the diagram's background color and font. The results related to the ease of use, shown in Figure 6.29, are very positive. Twelve (85.7%) participants voted 5 and 2 (14.3%) voted 4. As for how beneficial these features are, as seen in Figure 6.30, the results are a bit more mixed but lean towards being beneficial. 64.3% of the participants rated it more than 3, with five (35.7%) votes for 4 and four (28.6%) votes for 5. Then we have four (28.6%) votes for 3 (one of them being from the ND participant) and one (7.1%) vote for 2.

When asked to write some suggestions, some participants, due to their little to no knowledge about neurodivergence, weren't quite sure how these features would be beneficial to neurodivergent users:

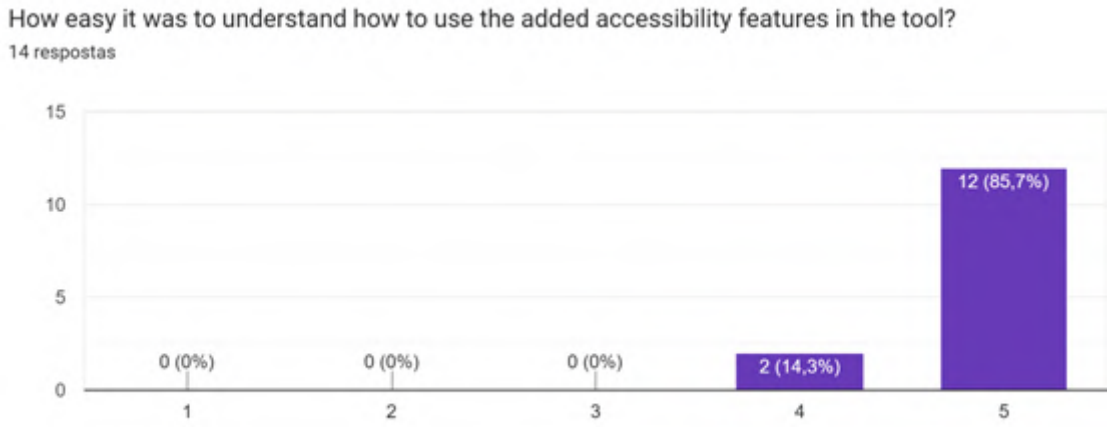


Figure 6.29: Results for the participants' opinion on the difficulty of using the accessibility options in the tool

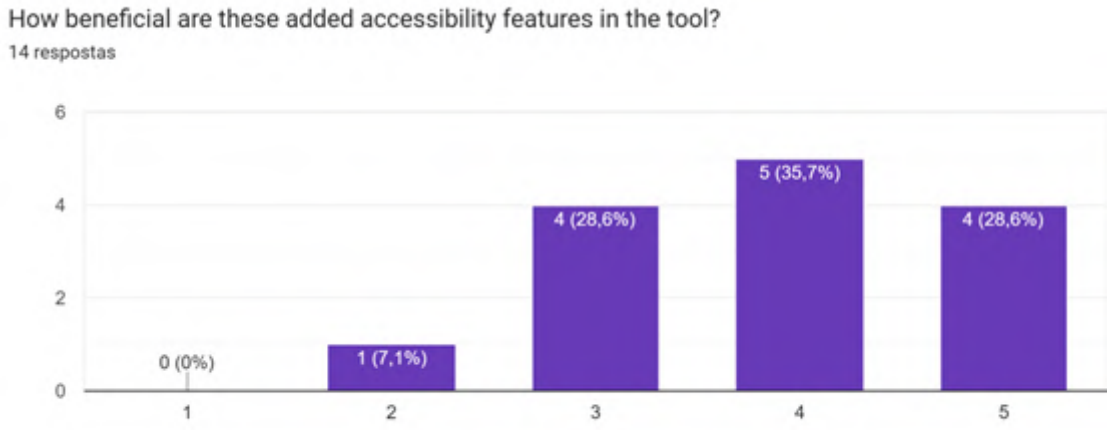


Figure 6.30: Results for the participants' opinion on the beneficial rate in using the accessibility options in the tool

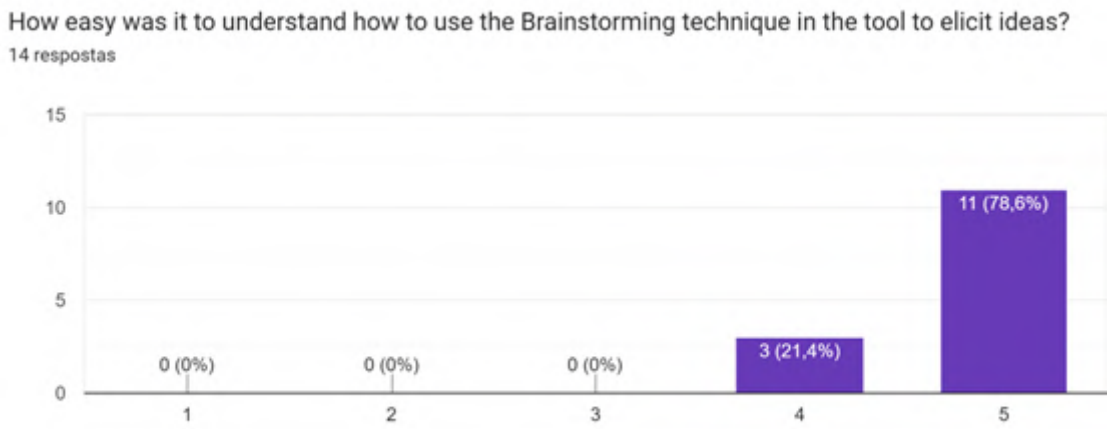


Figure 6.31: Results for the participants' opinion on the difficulty of using the Brainstorm technique in the tool

- "(...) I do not understand how the new features (changing colour) are related to ND users"
- "The shown examples are rather simple by changing color and font. Are these really the crucial aspects to improve the accessibility to ND?"
- "I am not familiar with characteristics of people with ND, however, the features seem to be too simple and I am not sure if only these will be enough"

We could have possibly linked some information we found to create our tables with guidelines for accessible interfaces for ND users in section 4.3 to inform participants of what has been studied before about this topic.

Our ND participant left a suggestion for another option to add: "Size and diagram color". Another participant suggested being able to control "the font size". These features were considered during its development, but due to time restraints were not implemented.

Brainstorm technique

Afterward, we solicited the viewpoints of the participants regarding the effectiveness of the Brainstorm technique.

The technique was mostly straightforward to understand for participants. As seen in Figure 6.31, 78.6% (eleven votes) of participants voted 5, and 21.4% (three votes) voted 4, showing very positive results again on this point.

As for the benefits added to this technique (wizard-style navigation, defining a problem/domain as a starting point), the opinions were diverse but closer to being beneficial. As shown in Figure 6.32, 42,9% (six votes) of participants voted 5 (one of them from the

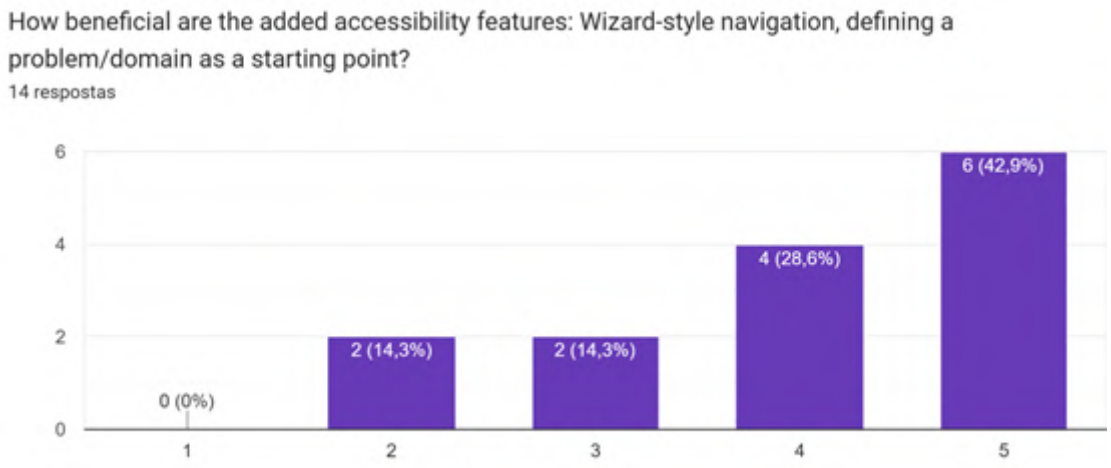


Figure 6.32: Results for the participants' opinion on the beneficial rate of using the Brainstorm technique in the tool

ND participant), followed by 28.6% (four votes) who voted 4, and finally 14.3% (two votes) for 3 and 2 each. Given that the only ND participant voted these additions and changes being very beneficial gives promise also being at least somewhat beneficial to other ND individuals.

The suggestions left for this technique are more directed towards aspects outside the actual technique itself

- "Is it possible that the ideas, when appearing, are organized (horizontally, for example), instead of "stacked"?"
- "The brainstorm requires multiple individuals. Does the tool allow multiple users in the same project? Each of them filling the ideas?"
- "The current problem and ideas are not in any way connected so that this information seems to be lost. Is it possible to have more than one brainstorming session on the same model? If so, how can I distinguish the different ideas from the different brainstorming sessions? What if different persons do a brainstorming on the same model?"

About that last suggestion of the previous list, we have some comments to add. Not only does it refer to the collaborative aspect of brainstorming like the second statement, which we would like to implement on a future version of the tool (although we especially chose this technique due to its easy translation to a solo activity), but it also refers to another important point missing currently from our tool. Currently, the tool can keep track of which elements were generated from an Idea node but can not trace from what creative

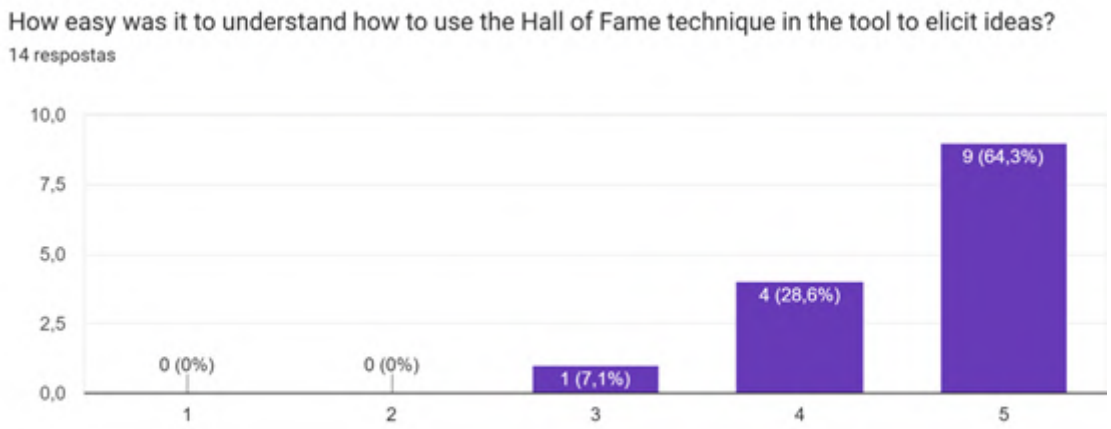


Figure 6.33: Results for the participants' opinion on the difficulty of using the Hall of Fame technique in the tool

technique and input the Idea came. This is another feature that could be implemented in the future.

Hall of Fame technique

Finally, participants were asked for their opinions on the changes to the Hall of Fame technique.

As it has been a pattern so far, the technique was very easy to understand how to use, as shown in Figure 6.33. 64.3% (nine votes) of participants voted 5, then 28.6% (four votes) voted 4, and 7.1% (one vote).

When considering if the accessible additions for this technique (reduce the amount of information shown, have Spark Clues for a more guided process) are beneficial, the overall results are similar to the Brainstorm technique. Five (35.7%) participants voted 5 (one of them from the ND participant) and other five voted 4, then three (21.4%) voted 4, and one (7.1%) voted 3, as shown in Figure 6.34.

As for the suggestions that were placed in the follow-up question, some participants pointed to previous comments left for the Brainstorm technique. As for the unique ones regarding this technique, we have the following:

- "It would have some relation between the personas and the model actors. For example, if the persona is a client of our system, is the "client" represented in the model? The idea can be transformed automatically to an association link to a concrete actor?"
- "Key aspects of the person could be highlighted in the description. That would also help with the focus"

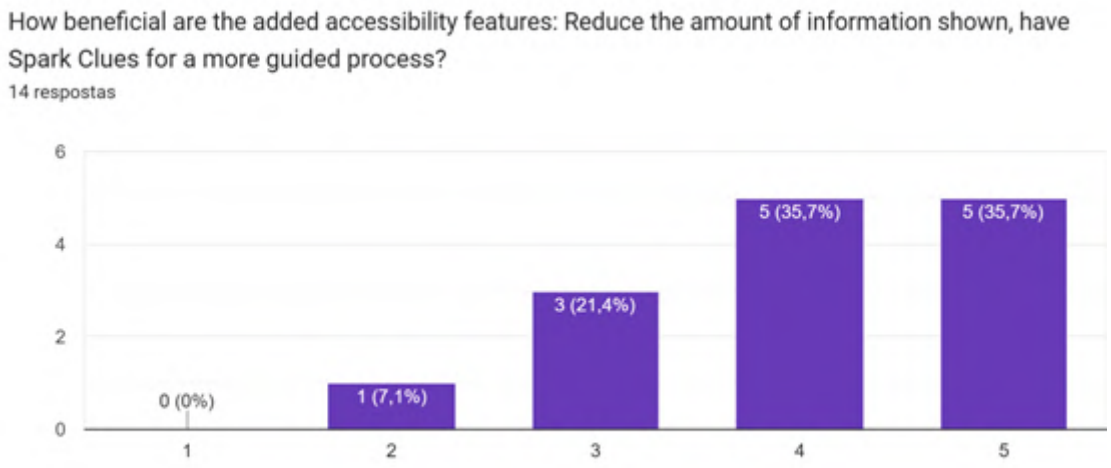


Figure 6.34: Results for the participants' opinion on the beneficial rate of using the Hall of Fame technique in the tool

Related to the first suggestion, we would like to point out that what the participant points out does align somewhat it how the Hall of Fame technique works in the Creative-Leaf tool. In that tool, the user must first select an actor before using the Hall of Fame technique and think of the persona as the selected actor. We wondered about implementing a similar feature in IdeaStar but rejected it due to limiting a persona to a specific actor. Yet, there could be some value in adding some extra input to inspire ideas for some ND users, so, we could reach a middle ground to allow the user to select an actor to base the persona on but not making that action obligatory.

Overall, we can say that looking at the results of this section along with the ones from Subsection 6.3.4 (as this section had more responses from ND participants), our main goal of developing a goal modeling tool based on an ND inclusive approach that is easy to use and accessible those with a neurodivergent condition was moderately achieved.

6.4 Threats to validity

After presenting and discussing our approach evaluation, we identified threats to validity using proposed guidelines [96] categorized as internal, external, construct, and conclusion validity.

6.4.1 Internal validity

Internal validity threats are factors that can impact the independent variable's causality without the researcher's knowledge[96].

While we tried to make our survey as concise and understandable as possible, it still may feel overwhelming to participants who did not know enough about either neurodivergent inclusivity issues or goal modeling to understand it. We tried to mitigate this risk by asking participants a series of questions about whether they had a neurodivergent condition or knowledge of the iStar language before answering questions related to those topics and leading them to different sections based on their condition or knowledge.

Moreover, we did not give enough information or resources about the struggles and strengths of neurodivergent individuals. This would have been a piece of valuable information to contextualize the reasoning for the concepts, and thus, provide participants the opportunity to give a more informed answer. Therefore, it constitutes a possible threat to the validity of the results. Still, this did give the opportunity to compare the perspectives of non-ND neurodivergent participants and the reality of those who answered and had an ND condition.

In addition, the total number of sections in the questionnaire is 13. However, the actual number of section one participant visits is either 6 or 10 depending on their answers in the profile sections of the survey. Plus, so as to not overload and exhaust the participant with too much information, especially since we are questioning participants with neurodivergent conditions, we tried to maintain a low number of questions in each section. The questions themselves were almost all multiple choice and open-ended questions were always optional. Still, most participants provided answers to the open-ended questions, suggesting this threat may have been mitigated.

6.4.2 External validity

Threats to external validity are conditions that limit our ability to generalize the results of our experiment to industrial practice [96].

While a considerable number of participants responded to the questionnaire within the given time frame, the validity of the evaluation results may be called into question due to the relatively small sample size. Therefore, it may not be appropriate to generalize the results from this sample to the entire population. This is especially true when it comes to the neurodivergent population of our questionnaire, which amounted to 7 participants, and is a group with a spectrum of experiences being neurodivergent.

Despite the limited number of participants, our sample had a relatively high representativeness, as some participants had been diagnosed while others were self-diagnosed, some either had ASD, others had ADHD, or both, and even one had dyslexia.

For those who had some experience in goal modeling, as we can see in Figure 6.8, out of all of those individuals, 71.4% of them were experts, with more than 5 years of experience. Although only one of those individuals was neurodivergent, which did leave a gap of participants who were both goal modeling experts and had a neurodivergent condition. We also didn't directly ask non-ND participants for their knowledge about neurodivergence, which poses a threat to the generalization of the results of certain

questions related to ND individuals. Still, given the fact that due to the factors related in Chapter 1 and the results of the systematic review in Chapter 3, the group of people who are both goal modeling experts and that have a neurodivergent condition is a very niche group. So, to have any amount of participants who fit this group is new and relevant information, even if it can not be generalized.

We were able to gather opinions from international researchers, thanks to both the video guide and the form being in English. However, some participants who were invited and responded to the form did not have English as their first language, which may have affected their understanding of the concepts presented in the video guide and the questions in the form. Despite this, the participants provided comprehensive responses to the open-ended questions in English and found the guide useful and easy to understand. As a result, we did not find any evidence of this decision having a negative impact.

6.4.3 Construct validity

When conducting an experiment, construct validity pertains to the ability to generalize the results to the underlying theory or concept of the experiment [96].

The construction of the questions in this study poses a threat to its validity. Specifically, the questions must accurately represent what they intend to ask in order to assess the study's goals. Additionally, it is possible that participants may not interpret the questions in the way that was intended. However, we took great care in constructing the questions through an iterative process that focused on simplifying the wording and ensuring objectivity, with the aim of removing any ambiguity. We also structured the form in distinct sections to provide participants with the context necessary to accurately respond.

6.4.4 Conclusion validity

Issues that may affect drawing correct conclusions about the relationship between treatment and experiment outcomes are referred to as threats to conclusion validity. [96].

To ensure the reliability of the conclusions reached, the questionnaire included a relatively high number of questions that were both quantitative and qualitative. These questions were designed to gather clear information about the participants' profiles, opinions, and viewpoints. This approach allowed us to collect enough information to mitigate the possibility of wrongfully concluding that there is or is not a relationship. However, the limited number of participants may pose a threat to the inferences made from the collected data and the conclusions of the evaluation.

6.5 Summary

This chapter presented the evaluation of the neurodivergent-inclusive approach to Software Engineering. First, we outlined the evaluation planning, including the goals of the

study and the concepts created to support them. We sought to understand the viewpoints of novices, practitioners, and experts on goal modeling.

As the inclusion of neurodivergent engineers in the software engineering field is still a somewhat recent topic being explored, we also collected the participants' perspectives on this topic to convey a more detailed discussion of the results. To achieve this, we created a questionnaire that included a video guide of the developed tool and collected both quantitative and qualitative data. Then, we described the participants' selection and invitation process. Finally, we presented and discussed the results of the evaluation.

The study yielded overall positive and promising results, providing this is a unique approach to the topic at hand. While we did receive some constructive critiques and suggestions, these opened up new avenues for future research. The feedback received from participants was very encouraging and gave us valuable insights for future improvement.

7

Conclusions

In this final chapter, we will discuss the contributions of the work presented in this dissertation. We will reflect on the goals we set for ourselves and highlight our main achievements. Lastly, we will provide suggestions for future research directions.

7.1 Problem Solution - Goal Modeling Accessible Tool Based On Creativity Methods

Inclusivity and equity are objectives that the Neurodiversity movement aims to achieve for those with diverse neurological conditions such as ASD, ADHD, and dyslexia. Today, thanks to scientific and technological knowledge and improvements, it is more plausible to find solutions to ensure a more inclusive world. However, inequality and exclusion are still a prominent part of a neurodivergent individual's life in various sectors of society. One of them is the Software Engineering field. Many software systems disregard the user experience, making it difficult for neurodivergent people to use them. This rigidity leads to poor adoption of tools and systems by organizations. Given the interest shown by neurodivergent individuals for the computer science field as a career choice, it is then important to address this problem to ensure future tools are neurodivergent-inclusive and benefit everyone.

In this dissertation, we studied neurodivergence issues in software engineering, which resulted in the proposal of a Requirements Engineering Approach for Accessibility of Neurodivergent Individuals.

This approach aims to support neurodivergent software and requirements engineers in the elicitation and analysis phases by providing IdeaStar, a neurodivergent inclusive goal modeling tool based on the iStar language. Its main objective is to facilitate the neurodivergent engineer's work through the existence of accessibility features and design choices directed at their needs, while also taking advantage of their strengths. This tool was developed with the aim of being accessible to both neurotypical and neurodivergent individuals, providing an inclusive user experience.

The knowledge regarding the key neurodiversity-related concepts was collected from

a systematic review of neurodiversity issues in software engineering. The study did not directly address the challenges faced by neurodivergent software engineers, revealing a gap in this field. However, the study's findings provided the foundation for the proposed approach and it contributes to the current state of knowledge in this area.

Given the information found in our systematic review, our previously mentioned tool works on three pillars: (1) Neurodivergent-inclusive User Interface; (2) Neurodivergent-Inclusive Creative Techniques; and (3) iStar Extension For Creative Requirements. The first pillar addresses the struggles certain neurodivergent engineers face when using software. The second pillar works of the neurodivergent creative strength given their unique cognitive way of thinking. The third pillar bridges and streamlines the creativity and goal modeling process by easily letting users document and translate their ideas gathered by creative techniques into actual iStar elements. This tool represents a first step towards neurodivergent inclusivity in the elicitation and analysis phases of requirements engineering in a useful, beneficial, and easy-to-use way.

As a final step, we empirically assessed the approach and tool to evaluate their usefulness and ease of understanding. The results were encouraging, and the feedback we received opened up new avenues for future research. During the evaluation, we also collected feedback from participants on the importance of including neurodivergent individuals in requirements engineering. The results demonstrated the relevance of our work.

7.2 Contributions

We highlight the following achievements:

- A contribution to the state of the art on neurodiversity issues in software engineering (Chapter 3).
- A set of neurodivergent-inclusive HCI guidelines focused on individuals with ASD, ADHD, and Dyslexia (Section 4.3).
- A classification for the appropriateness of creative techniques for different neurodivergent conditions (Section 4.4).
- An iStar extension for creative requirements (Section 4.5).
- The IdeaStar tool, a first version of a goal modeling tool to integrate the neurodivergent inclusive approach into requirements elicitation and analysis techniques (Chapter 5).
- An empirical evaluation of the approach with 25 participants, 6 of them being neurodivergent from varying conditions (Chapter 6).

The intersection of neurodiversity with computer-related technologies is well studied in Humanities disciplines, such as Psychology, and Social Sciences, and the field of Human-Computer Interaction. This interdisciplinary research laid the foundation to better understand the impact and importance of neurodiversity in the context of software development.

Despite the growing knowledge of neurodiversity, it has not yet been fully integrated into Requirements Engineering. This study aims to contribute to the understanding of neurodiversity inclusivity issues in the field of Requirements Engineering, which is an important step towards the inclusion of neurodivergent engineers. Additionally, we hope that this work will help in further analyzing and advancing this topic in the Humanities disciplines.

7.3 Future work

This work resulted in the proposal of an approach to the inclusivity of neurodivergent engineers in the Requirements Engineering process. However, there is still a long road to follow to successfully develop truly inclusive systems that benefit everyone.

For future work, we list the following possible approaches and research opportunities regarding the presented approach:

- Despite the positive results in the evaluation of the approach, its concepts and relations could be further refined. This is especially true in the case of the iStar extension, where a lot of suggestions were given to improve it, such as the graphical notation, the naming convention of the links, and the coverage of other possible types of connections.

- Furthermore, the approach only considered three types of neurodivergent conditions. Neurodiversity includes many other conditions such as Dyspraxia, Dyscalculia, Tourette's syndrome, Auditory Processing Disorder, and Irlen Syndrome [62]. To bring true inclusivity status, individuals with these conditions should not be left out of the approach. So, more research and solutions should be done on this topic.

- No one neurodivergent individual with the same condition has the same needs and wants. Our approach has developed based on the information we found during the systematic review. While we found out that, for example, having reduced information shown for individuals with ADHD might be beneficial, as the evaluation showed us, this is not true for all individuals with that condition. More options and freedom of choice should be considered within the approach to include a broader range of characteristics for each condition.

- In the performed evaluation, we were able to get some neurodivergent computer science engineers to respond to our survey. However, only one of them had any experience in goal modeling. Given that iStar is a big part of one of the pillars of

the approach, it would be valuable to in the future contact more individuals who fit that category to get a more complete perception of the full approach rather than part of it.

- Besides the number of participants for a future survey, another important aspect would be to move on to a more dynamic evaluation where the neurodivergent participants would be able to try the tool themselves. This would provide insightful and valuable feedback for improvement. This evaluation should also compare the use of the base piStar tool with IdeaStar and compare the results to understand the true benefits of such additions.

- Further developments of the IdeaStar tool are needed to refine and complete the approach: more accessibility options like font size, color contrast, zoom, and others should be added; more options to control the level of freedom when using a creative technique; more ways to document and organize the elicited ideas; add more traceability to the generated idea nodes; allow for better version control of the models to consider different ideas and possibilities; and allow for collaborative work.

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A

Appendix 1 Creative Techniques

Technique	Description	Source
Goal modeling	Consists in the use of goal models (i*, KAOS,...) during RE activities as part of a creativity methodology guided by tool-support.	[26]
Roles playing	Consists in the use of different roles (e.g. explorer, artist, judge, and warrior) to focus the participants on ideas generation from diverse and unexpected perspectives.	[26]
Hall of fame	This creativity technique helps the participant to take a step away from the most obvious and reasonable perspectives by consulting the world great minds. The participants used these characters to force connections and generate new requirements for their projects by consulting the famous people.	[26]
Viewpoints	This technique aims to model the domain from different perspectives in order to develop a complete and consistent description of the target system.	[26]
Questions list	Consists in the use of questions as a means to support divergent thinking.	[26]

Heuristics	A heuristic technique is a rule of thumb, strategy, trick, simplification, or any other kind of device which drastically limits search for solutions in large problem spaces. Heuristics do not guarantee optimal solutions; in fact, they do not guarantee any solution at all; all that can be said for a useful heuristic is that it offers solutions which are good enough most of the time.	[26]
Why why why?	This technique urges the users to constantly question the motivation for each element of a system design. This, obviously, can help the user to move up the model, adding higher level intentions until the why question is no longer sensible.	[26]
Assumption-busting	Assumption-busting works by deliberately seeking out and addressing these previously-unquestioned assumptions.	[84]
Attribute Listing	Attribute Listing works as a decompositional approach, breaking the problem down into smaller parts that can be examined individually. All things have attributes which are sometimes overlooked. By deliberately focusing on these, you can find new ways to be creative.	[84]
Breakdown	Many problem situations are hierarchical in nature, and will yield to breaking down into component parts. Doing this slowly and carefully allows attention to be paid to how the whole system works, and hence enable the discovery of problems and the triggering of ideas.	[84]
CATWOE	CATWOE was defined by Peter Checkland as a part of his Soft Systems Methodology (SSM). It is a simple checklist for thinking. Like many checklists, it can be surprisingly useful when used appropriately to stimulate open thought.	[84]

Day In The Life	Context is an important part of creating meaning. Putting the rest of life around experiencing a problem or using a solution enables a deeper understanding to be gained.By seeing through the eyes of target people, it is easier to associate with their feelings and experiences and really understand their contextualized need and problems.Story formats are often easier to understand than business reports. Story is a natural communication medium and hence 'make sense' in a more holistic way. When you can really see their problems, then this creates a more effective creative tension that you can use for generating effective solutions.	[84]
The Kipling method (5W1H)	Rudyard Kipling used a set of questions to help trigger ideas and solve problems and immortalized them in the poem: I have six honest serving men They taught me all I knewI call them What and Where and When And How and Why and Who. These questions can be used as stimuli to get thinking going in many situations.	[84]
How to	How to' effectively asks a question without phrasing it as a question. This sets up a creative tension that gets the subconscious engaged with thinking about ways to solve the problem that is inherently stated.	[84]
Is - Is not	Is-Is not analysis works by making you deliberately think about the problem and in particular the boundaries of what it is or is not. It thus helps to create focus in attention and consequently is more likely to lead to the right problem being solved - it is a very common issue that an unclear boundary can lead to wandering off the path and solving unimportant problems.	[84]

PSI	PSI uses the principle of forced association, which gets your brain out a rut by bringing together things that have not previously been combined. In its flight from the discomfort of this, the subconscious brain will give you whatever you want, including useful ideas.PSI takes this a step further by deliberately using the problem as one part of the combinatory equation.	[84]
Random Words	Find a random words that will be used as a stimulus for new ideas.	[84]
SCAMPER	SCAMPER is an acronym for useful list of words that can be applied as stimuli to make you think differently about the problem area.	[84]
Idea box	The Idea Box technique starts by stating a challenge, followed by selecting the parameters of the stated challenge. Then, a list of options for each parameter is created, and finally, the participant should try different combinations to find new concepts and requirements.	[26]
Topic maps	A topic map consists of a set of nodes, linked by associations. A node may fill a specific role in an association. The representation mechanism also supports the subclass relation and the instance-of relation.	[26]
Scenarios	Scenarios are narrative and specific descriptions of current and future processes including actions and interactions between the users and the system.	[26]
Combining ideas	This technique creates new ideas from a combination and synthesis of existing ideas.	[26]

Combinational creativity	This technique "extracts familiar ideas from the requirements and stakeholders' comments using topic modeling and applies part-of-speech tagging to obtain unfamiliar idea combinations". The framework starts with a social network based on stakeholders' social interaction, goes through several phases involving techniques, such as clustering, topic modeling, POS tagging, and similarity analysis, and ultimately creates new requirements in an automated manner.	[26]
Brainstorming	Brainstorming is a process where participants from different stakeholder groups engage in informal discussion to rapidly generate as many ideas as possible without focusing on any one in particular. It is important when conducting this type of group work to avoid exploring or critiquing ideas in great detail.	[26]
Deconstruction	The basic idea of this technique is to start with the usual perception the developers had of their products and step-by-step remove certain constituents. Then the participants would need to replace them with something else.	[26]
Design rationale	Design rationale, in simple words, is information which represents and explains the reasoning behind the requirements engineering process.	[26]
Challenge	One way in which we deal with the complexity of the world is to make assumptions about many things. Our pattern-matching ability is a great help in allowing us to take short-cuts but it often ends up in us not noticing many things. If we do not take deliberate and conscious action, our subconscious will let many assumptions pass by unnoticed.	[84]

Chunking	Chunking down uses the principle of decomposition, breaking things down into smaller pieces. Chunking up simply reverses this to get a higher-level viewpoint.It also works by moving people from their preferred chunk level to a platform where they normally do not go (note, for example, how some people dive instinctively into the detail).	[84]
Physualization	Physualization is the physical manipulation of visualization entities – it is not just visualization for the sake of communicating or creating a record. Physualization actively promotes physical manipulation to help participants explore possibilities in the requirement and design spaces by engaging more of their sensory and cognitive processes – possibly leading to improvements in the requirements process and resulting artifacts.	[26]
Picture stimulation	In this technique a particular problem or idea can be reinvented using different angles motivated from pictures.	[26]
Analogies	Analysts use previous experience in similar domains as a discussion template for facilitating group work and conducting interviews. Analogies and abstractions of existing problem domains can be used as baselines to acquire specific and detailed information, identify and describe possible solution systems.	[26]
Presenting solution space knowledge	In this technique people change the solution space in a way that things that were considered impossible are now possible.	[26]
Constraints removal	This technique identifies and challenges the current constraints of the system in order to eliminate them in a new solution.	[26]

Storyboard	Storyboard is an extended version of the Scenarios technique. Beyond textual descriptions for a scenario, it combines visual representations with graphics and text to describe system behaviors in a concrete form directly observable by stakeholders.	[26]
Creativity Workshops	Workshop is a generic term given to a number of different types of group meetings where the emphasis is on collectively developing and discovering requirements for a software system.	[26]
Walt Disney	This technique decomposes the creative process into three different steps called Dreamer, Critique, and Realist, respectively. Each of these steps would usually lead to prolonged sessions, which could easily need several hours. While the basic goals of these steps are well defined, their detailed performance is hardly defined and no detailed guidance on their performance is given.	[26]
Game mechanics	This technique provides levels and goals, which can be in the form of awards, credits and acknowledgements, in order to motivate and engage participants in the creative problem solving process.	[26]
Positive space design	Space design refers to the context in which creativity takes place, including its environment, place, situation and climate. It can also refer to the environment the person is in, the product that is produced or the process that takes place, and explains the interaction between the person and situation that can promote (positive) or inhibit creativity.	[26]
Creative spaces for conversations	Consists in the use of spaces that embrace creative conversations. The spaces bring together many project stakeholders and the creative team to address the social challenge in creative and innovative ways.	[26]

Constructivist learning	Constructivist learning refers to two knowledge building mechanisms: assimilation and accommodation. Through assimilation, the learner interprets and incorporates new knowledge into an existing conceptual framework representing his or her knowledge of a topic area. Accommodation occurs when the learner could not fit the new learning into his or her existing framework, as a result he or she reframes (restructures) the existing conceptual framework.	[26]
Walkthroughs	The requirements engineer leads stakeholders through a segment of documentation and the participants ask questions and make comments about possible errors, violations, omissions and other problems. The big idea behind walkthroughs is very simple: people are better at recognition than recall.	[26]
Speed modeling	It is a 3D form of brainstorming. Rather than exploring a subject area or question through a typical, written brainstorming, a facilitator poses a number of questions that participants have to answer by modeling with Plasticine within 30 seconds to three minutes. The time limit encourages quick thought and prevents participants from feeling conscious of the quality of their creativity and ability to express it.	[26]
Cultural probing	Cultural probing is a technique which allows the user to carry around a probe designed to provoke inspirational responses in different circumstances.	[26]
Influence positive emotions	Positive emotions technique seeks to adapt the way people think and act such that creativity during idea generation is augmented. Interactive systems can be designed to stimulate and influence participants' emotions and get more out of their own creative capabilities.	[26]

Table A.1: Description and source for each creative technique gathered

B

Appendix 2 Evaluation Questionnaire

A Software Engineering Approach for Accessibility of Neurodiverse Individuals

The purpose of this questionnaire is to evaluate the concepts and the resulting tool of a neurodiverse-inclusive Software Engineering approach developed in the context of an MSc dissertation in Computer Science and Informatics at NOVA School of Science of Technology in Almada, Portugal.

Studies have shown that neurodivergent (ND) individuals (such as those with Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), Dyslexia) have an affinity towards the Computer Science field. However, most of the time their unique cognitive styles (strengths and struggles) aren't taken into consideration. Despite some efforts (e.g.. Microsoft's ND recruiting initiative) to make this area of engineering more accessible, a lot as still to be done.

Our approach aims at contributing to make requirements elicitation and analysis more accessible to ND.

Please read the guide before answering this questionnaire.

This questionnaire is aimed for professionals in software engineering or computer science who fit any of the following criteria:

- Are familiar with goal modeling and the iStar language but **do not have** a ND condition (ASD, ADHD or Dyslexia);
- Have some ND condition (ASD, ADHD or Dyslexia) **and are not** knowledgeable in Goal Modeling or iStar;
- Have some ND condition **and are** knowledgeable in Goal Modeling or iStar.

Answers will be kept in accordance with privacy regulations such as GDPR. Aggregated and anonmyised data may be used in the MSc dissertation or published as a part of a scientific publication. By participating in this survey, you consent to these terms.

This questionnaire will take around 20 minutes to answer at most. If you are interested in the results of this work, please contact me.

Thank you so much for your help and time to participate in this survey. Your availability is very much appreciated.

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Supervisors

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- Grischa Liebel (grischal@ru.is)

* Indica uma pergunta obrigatória

Pre-survey Profile

1. What is your age? *

Marcar apenas uma oval.

- ◯ Under 18
- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65 and over

2. What is our gender? *

Marcar apenas uma oval.

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ Prefer not to say
- ◯ Outra: _____

3. What is your level of academic training? *

Marcar apenas uma oval.

- ◯ Bachelor
- ◯ Master's Degree
- ◯ PhD
- ◯ Outra: _____

4. What is your main occupation? *

Marcar apenas uma oval.

- ◯ Industry professional
- ◯ Researcher
- ◯ Student
- ◯ Academic/university lecturer
- ◯ Outra: _____

5. Have you been diagnosed or self-diagnosed with a neurodivergent condition? *

Marcar apenas uma oval.

- ◯ I have been diagnosed with a condition *Avançar para a pergunta 7*
- ◯ I'm self-diagnosed with a condition *Avançar para a pergunta 7*
- ◯ I don't have any condition *Avançar para a pergunta 12*

6. If you answered "Yes" to the last question, please refer to which of the following neurodiverse conditions you have been diagnosed or self-diagnosed with?

Marcar tudo o que for aplicável.

- ☐ Autism Spectrum Disorder (ASD)
- ☐ Attention Deficit Hyperactivity Disorder (ADHD)
- ☐ Dyslexia
- ☐ Outra: _____

Neurodivergent Inclusive User Interfaces (UI) Guidelines

We define engineering tools as tools/methods/practices to be used in engineering.

The following questions relate to the accessibility of User Interfaces (UIs) towards neurodivergent individuals during the development of engineering tools.

7. How important it is to offer **accessible UIs for different kinds of individuals** when developing engineering tools? *

Marcar apenas uma oval por linha.

	1 - Not important	2	3	4	5 - Very important	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

8. Rate your agreement to the following statements regarding addressing **accessible UI issues** in the software development of engineering tools? *

Marcar apenas uma oval por linha.

	1 - Strongly disagree	2	3	4	5 - Strongly agree	Don't know
Accessibility issues are an afterthought in the development of engineering tools.						
Accessibility issues should be thought out as early as possible during the development of engineering tools.						
The benefits obtained by making tools accessible do not warrant the costs.						

9. How beneficial would the following features be in an engineering tool to do your work more efficiently? *

Marcar apenas uma oval por linha.

	1 - Not beneficial at all	2	3	4	5 - Very beneficial	Don't know
Option to change the background color	◯	◯	◯	◯	◯	◯
Option to change the font	◯	◯	◯	◯	◯	◯
Wizard-style navigation for forms (ie. having a separate page for each step)	◯	◯	◯	◯	◯	◯
Reduce the amount of information shown at once	◯	◯	◯	◯	◯	◯

10. Is there any other accessibility feature(s) that you, as a neurodivergent individual, feel should be present in an engineering tool that would make your job easier?

11. When using engineering tools, how affected are you by the lack of accessibility features when using these tools? *

Marcar apenas uma oval por linha.

	1 - Not affected at all	2	3	4	5 - Very affected	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

Avançar para a pergunta 15

Neurodivergent Inclusive User Interface (UI)

We define engineering tools as tools/methods/practices to be used in engineering.

The following questions relate to the accessibility of User Interfaces (UIs) towards neurodivergent individuals during the development of engineering tools.

12. How important it is to offer **accessible UIs for different kinds of individuals** when developing engineering tools? *

Marcar apenas uma oval por linha.

	1 - Not important	2	3	4	5 - Very important	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

13. Rate your agreement to the following statements regarding addressing **accessible UI issues** in the software development of engineering tools ? *

Marcar apenas uma oval por linha.

	1 - Strongly disagree	2	3	4	5 - Strongly agree	Don't know
Accessibility issues are an afterthought in the development of engineering tools.	◯	◯	◯	◯	◯	◯
Accessibility issues should be thought out as early as possible during the development of engineering tools.	◯	◯	◯	◯	◯	◯
The benefits obtained by making tools accessible do not warrant the costs.	◯	◯	◯	◯	◯	◯

14. When developing software, how much effort do you put into adding accessibility features into it? *

Marcar apenas uma oval por linha.

	1 - No effort	2	3	4	5 - A lot of effort	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

Avançar para a pergunta 19

Creativity In Software Development

Creativity refers to the generation of ideas, solutions, and artifacts that are novel and useful, and creative techniques refer to methods/techniques that support creativity and the generation of novel ideas.

The following questions are related to the use of creativity and creative techniques in software development.

15. In your opinion, how important is creativity during software engineering? *

Marcar apenas uma oval por linha.

	1 - Not important	2	3	4	5 - Very important	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

16. Rate your agreement to the following statements in relation to **creativity** in software development? *

Marcar apenas uma oval por linha.

	1 - Strongly disagree	2	3	4	5 - Strongly agree	Don't know
Creativity is often frowned upon in most work environments in favour of productivity and time constraints.						
Creativity can only be incentivized up to a certain point, as other matters may take priority.						
Creativity is a no issue since development is already taking place in environments that facilitate novelty and curiosity, and thus creativity in software development projects.						
Creativity does not play an important role in software engineering						

projects engineering projects.

17. Do you feel that adding creativity techniques to engineering tools would be aligned with your way of thinking? *

Marcar apenas uma oval.

- Yes
- No

18. If you answered "Yes" in the previous question which of the following would be the benefits of adding creativity techniques?

Marcar tudo o que for aplicável.

- [ ] Having a space that allows me to be creative would make my voice heard.
- [ ] Using creative techniques allows me to present ideas that might be different from the norm, adding a novel quality to them.
- [ ] If the problem being solved aligns with my interests, it would allow me to use my extensive knowledge to solve said problem.
- [ ] Outra: _____

Avançar para a pergunta 21

Creativity In Software Development

Creativity refers to the generation of ideas, solutions, and artifacts that are novel and useful, and creative techniques refer to methods/techniques that support creativity and the generation of novel ideas.

The following questions are related to the use of creativity and creative techniques in software development.

19. In your opinion, how important is creativity during software engineering? *

Marcar apenas uma oval por linha.

	1 - Not important	2	3	4	5 - Very important	Don't know
Choose one option	◯	◯	◯	◯	◯	◯

20. Rate your agreement to the following statements in relation to **creativity** in software development? *

Marcar apenas uma oval por linha.

	1 - Strongly disagree	2	3	4	5 - Strongly agree	Don't know
Creativity is often frowned upon in most work environments in favour of productivity and time constraints.						
Creativity can only be incentivized up to a certain point, as other matters may take priority.						
Creativity is a no issue since development is already taking place in environments that facilitate novelty and curiosity, and thus creativity in software development projects.						
Creativity does not play an important role in software engineering						

projects engineering projects.

Avançar para a pergunta 21

Profile (Part 2)

21. What is your experience with goal modeling, particularly with the i* language? *

Marcar apenas uma oval.

- I have no experience with iStar. *Avançar para a pergunta 22*
- 1-2 years
  Avançar para a secção 9 (iStar Extension For Creative Requirements)
- 3-5 years
  Avançar para a secção 9 (iStar Extension For Creative Requirements)
- 5+ years
  Avançar para a secção 9 (iStar Extension For Creative Requirements)

Neurodivergent (ND) Inclusive Creative Techniques

The following questions are related to two creative techniques, particularly Brainstorm and Hall of Fame, as well as the changes that were made to those techniques to make their use more accessible to ND in a web application.

Brainstorm

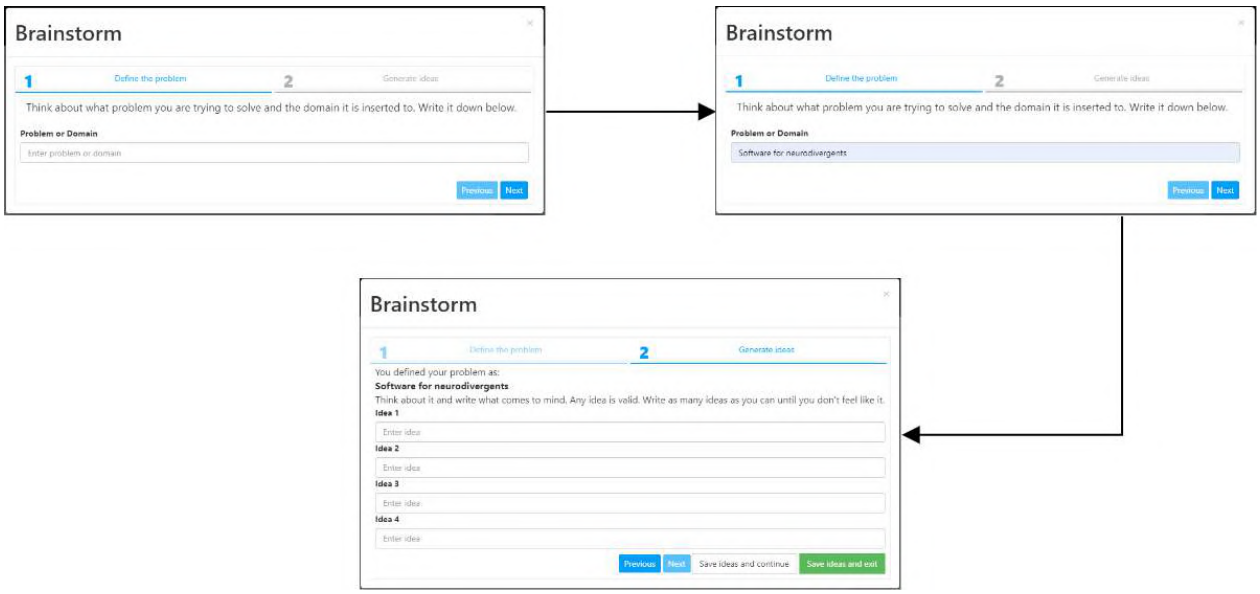
The image below shows our version of the Brainstorm. This is a technique were the person is free to think about whatever comes to their mind and register as many ideas as possible without focusing too much on one idea in particular.

We have added two features to make it more accessible to ND:

- **Wizard-style navigation** (i.e. having different separate pages for each task). This adds clarity to the user as for how many tasks they need to do to finish and what which task will require them to do beforehand;
- **Ask for a problem/domain definition** before the main Brainstorm task. This gives a starting point as opposed to having this technique be too open-ended.

The user can go back and forward by using the Previous and Next buttons or the navigation bar. After filling the input boxes, they can save the currently written ideas and clean the input boxes using the "Save ideas and continue" button or save the written ideas and finish the Brainstorm session using the "Save ideas and exit" button.

Brainstorm with the previously described features. Right-click on the image and press "Open on a new tab" to view a bigger version of it.



22. How beneficial to ND are the added accessibility features: **Wizard-style navigation, defining a problem/domain as a starting point**? *

Marcar apenas uma oval.

	Not beneficial				Very beneficial
	1	2	3	4	5

23. If you have any other features/ideas to make **Brainstorming** more accessible to ND please suggest them here.

Hall of Fame

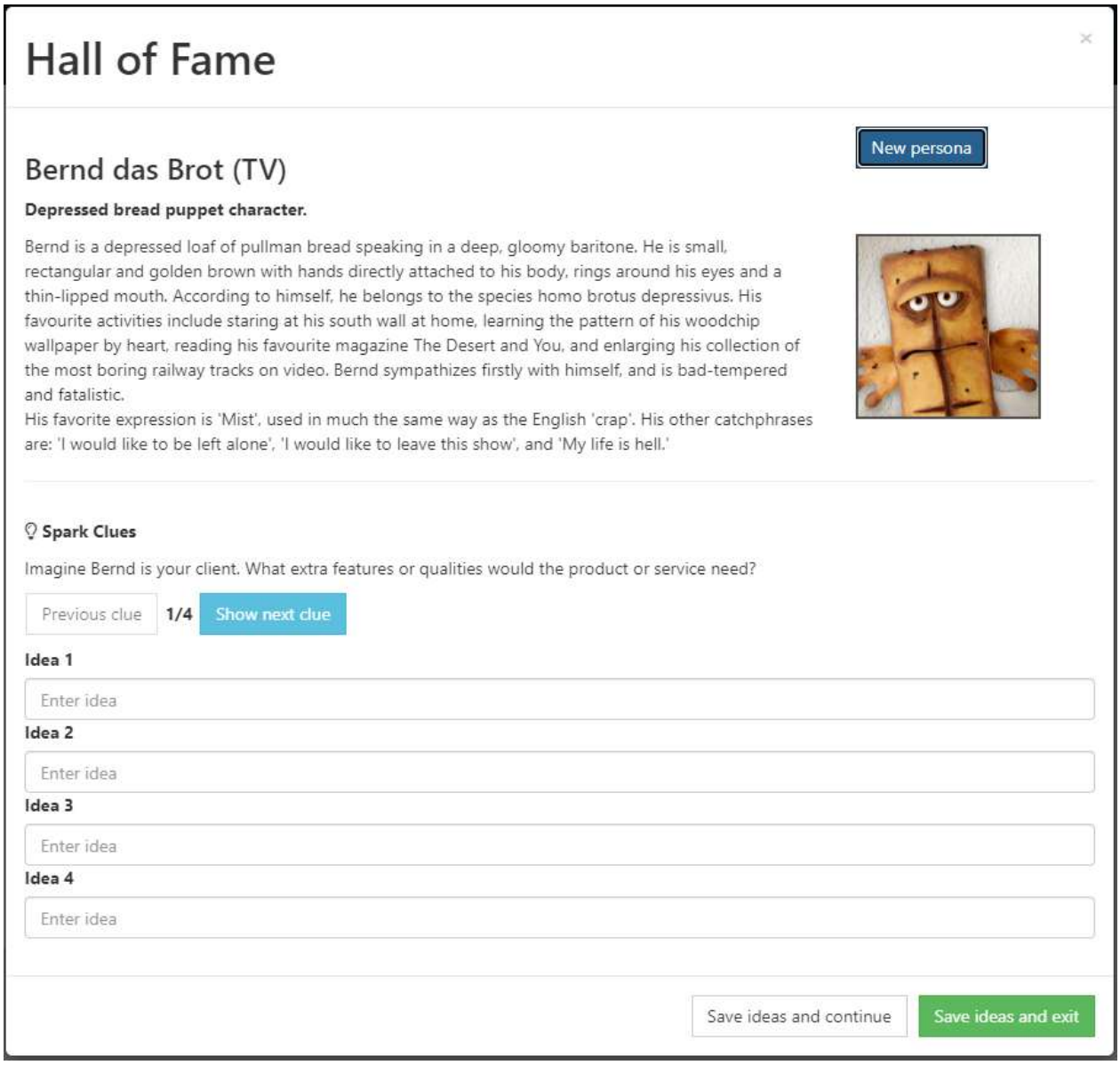
The following figure is our version of the Hall of Fame. This technique uses different famous fictional/real personas as inspiration to generate ideas from a different perspective from our own.

Our version has two added features to make it more accessible to ND:

- **Spark Clues.** This gives an extra source of inspiration for a guided process along the way;
- **Reduced information shown at once.** Instead of showing all of the available spark clues at once, we only show one at a time to not overwhelm the user with too much information at once.

After filling in the input boxes, you can save the currently written ideas and clean the input boxes using the "Save ideas and continue" button or save the currently written ideas and finish the session using the "Save ideas and exit" button.

Hall of Fame with the previously described features shown



24. How beneficial to ND are the added accessibility features: **Reduce the amount of information shown, have Spark Clues for a more guided process**? *

Marcar apenas uma oval.

	Not beneficial
1	◯
2	◯
3	◯
4	◯
5	◯
	Very beneficial

25. If you have any other features/ideas to make **Hall of Fame** more accessible to ND please suggest them here.

For SurveyCircle users, www.surveycircle.com (ignore if you didn't find this survey from there)
The Survey Code is: RFQK-Z6Z6-SCAG-CJPS

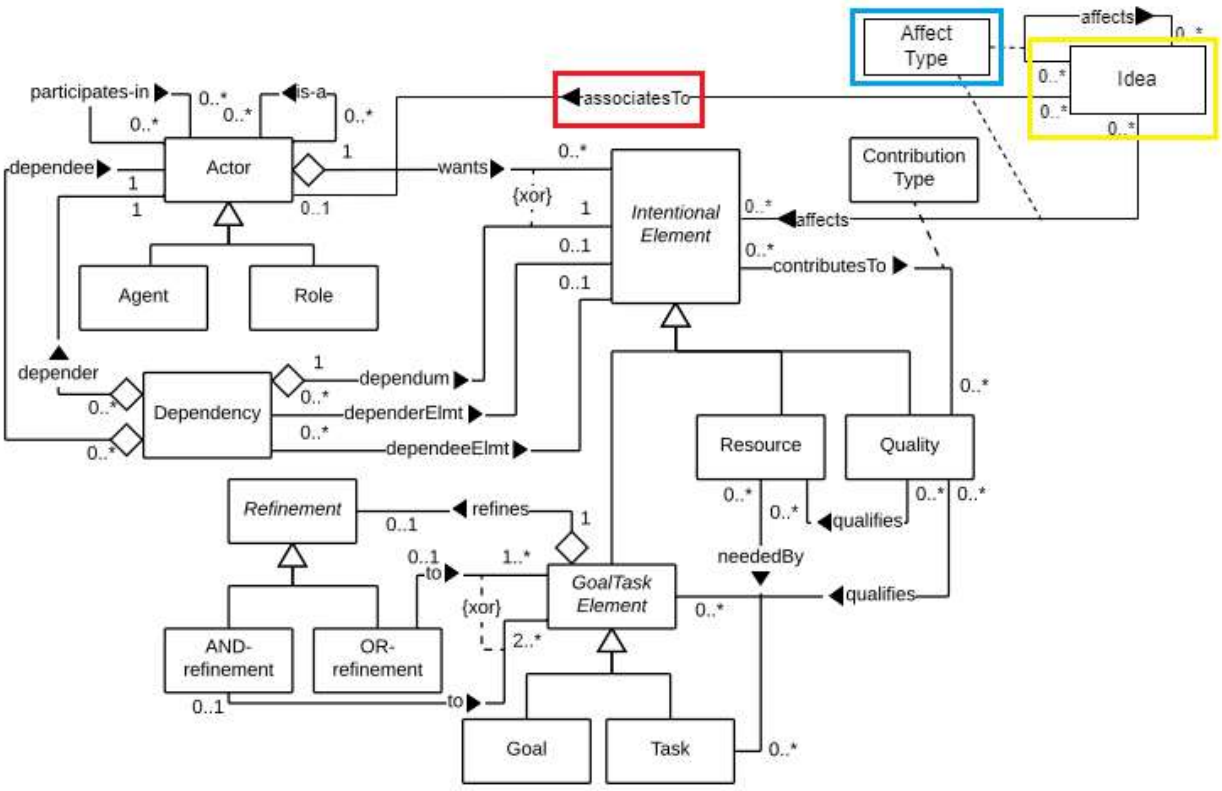
iStar Extension For Creative Requirements

The iStar Extension For Creative Requirements extends the iStar language to support the use of creativity techniques; the generated ideas can be easily transformed into iStar elements.
The following steps show how to use this extension:

1. Choose a creative technique, such as Brainstorming, Hall Of Fame;
2. Generate ideas using the selected technique; this will allow the use of *Idea* nodes;
3. For each idea that you believe might have the potential to be represented in the model, do:

3.1 If it applies, connect an idea to the most related actor using an *Association* link type;
3.2 Consider how the Idea node affects other *Intentional Elements* or even other *Idea* nodes and connect to them using an *Affect* link type (which can either *motivates* or *restricts);*
3.3 Finally, analyze connections between Ideas and the other elements of the model and think about what kind of iStar elements and links they can be turned into.

The following is the metamodel for the iStar extension with the new additions: Idea node, Affect type link, and Association link (highlighted with yellow, blue, and red rectangles, respectively).



iStar Extension Part 1. Idea node

The Idea node allows for representing a certain new aspect of the problem or the model; its generation comes from using creative techniques.

Idea node representation in iStar

26. Do Idea nodes help bridge the use of creative techniques and generate new iStar elements for the model? *

Marcar apenas uma oval.

- Yes
- No

27. If you answered "No" to the previous question, please give your suggestions about what could be improved.

iStar Extension Part 2. Association and Affect Links

The *Association* link represents a relationship between an idea and an actor. An idea is associated with **one and only one** actor.

The *Affect* link has two different types, *motivates* and *restricts*.

The *Motivates* link represents a relationship between an idea and/or iStar intentional elements (goal, quality, task, and resource); that is, an idea *motivates* an intentional element or another idea.

The *Restricts* link also represents a relationship between an idea and/or intentional elements (goal, quality, task, and resource); that is, an idea *restricts* an intentional element or another idea.

Association link representation in iStar

Motivates link representation in iStar

Restricts link representation in iStar

28. Are these added links enough to reflect the possible relationships between Idea nodes and other iStar elements in the model? *

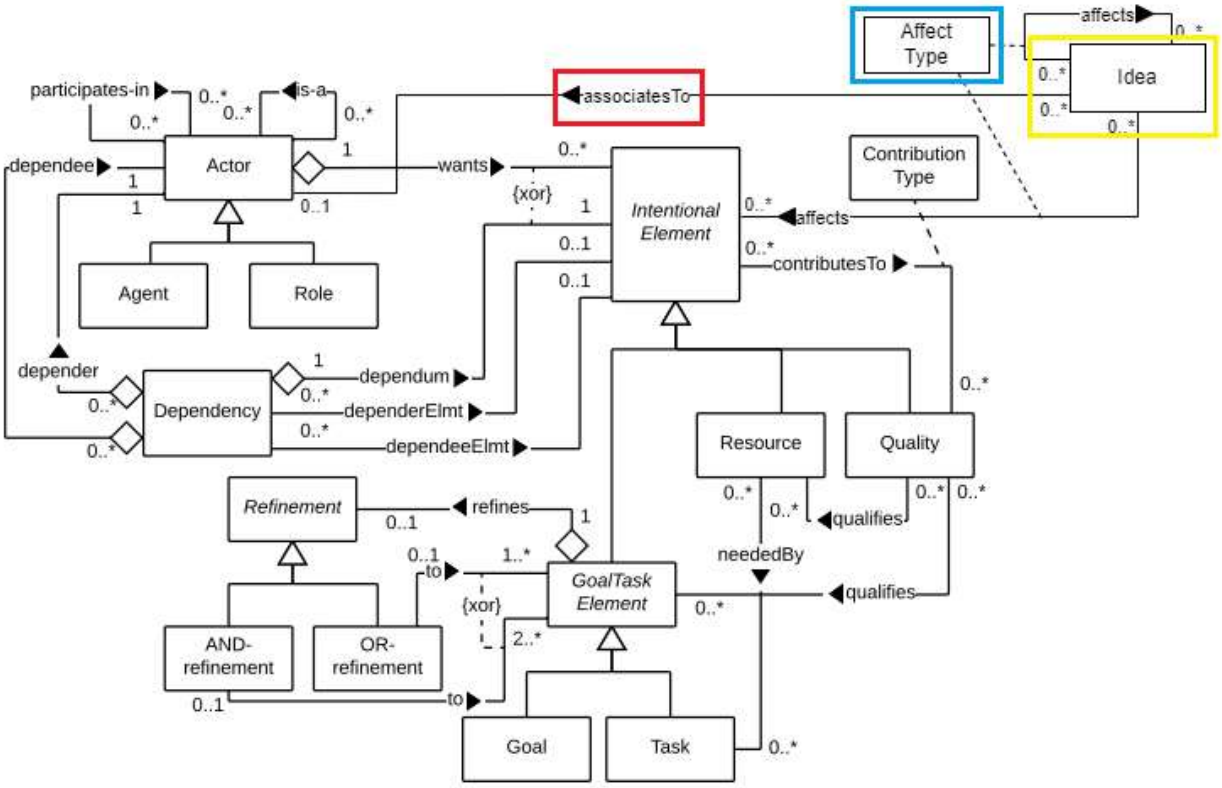
Marcar apenas uma oval.

- Yes
- No

29. If you answered "No", please give your suggestions on how this could be improved.

iStar Extension Part 3. Overall Opinion of the iStar extension

For each of the following questions, please provide the answer that better reflects your opinion about this iStar extension.



30. How useful is this iStar extension to create new and original requirements? *

Marcar apenas uma oval.

Not useful

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very useful

31. How difficult it is to understand this iStar extension? *

Marcar apenas uma oval.

Not difficult

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very difficult

32. What are the strongest points about this iStar extension?

33. What are the weakest points of this iStar extension?

IdeaStar Tool

The following videos show the main features of the tool prototype IdeaStar. IdeaStar implements the concepts discussed in this questionnaire. The tool is built on the piStar tool. We will only show the added features (more details on piStar can be found here). The source code of IdeaStar can be downloaded here.

For each of the following questions, please provide the answer that better reflects your opinion about IdeaStar.

IdeaStar Demo - Introduction

http://youtube.com/watch?v=CCnoWUtjc28

34. "How easy was it to understand the use of the added iStar elements in the tool? *

Marcar apenas uma oval.

Not easy at all

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very easy

IdeaStar Demo - Options

http://youtube.com/watch?v=wb-RJnXvebA

35. How easy it was to understand how to use the added accessibility features in the tool? *

Marcar apenas uma oval.

Not easy at all

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very easy

36. How beneficial are these added accessibility features in the tool? *

Marcar apenas uma oval.

	Not beneficial				Very beneficial
	1	2	3	4	5

37. If you have any other features to make this part of the tool more accessible to ND, we would be thankful for your suggestions.

IdeaStar Demo - Brainstorming

http://youtube.com/watch?v=nyIFInECpdo

38. How easy was it to understand how to use the Brainstorming technique in the tool to elicit ideas? *

Marcar apenas uma oval.

	Not easy at all					Very easy
	1	2	3	4	5	

39. How beneficial are the added accessibility features: **Wizard-style navigation, defining a problem/domain as a starting point**? *

Marcar apenas uma oval.

Not beneficial

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very beneficial

40. If you have any other features to make this part of the tool (Brainstorming) more accessible to ND, we would be thankful for your suggestions.

IdeaStar Demo - Hall of Fame

http://youtube.com/watch?v=9OTrot_Ef6M

41. How easy was it to understand how to use the Hall of Fame technique in the tool to elicit ideas? *

Marcar apenas uma oval.

	Not easy at all				Very easy
	1	2	3	4	5

42. How beneficial are the added accessibility features: **Reduce the amount of information shown, have Spark Clues for a more guided process**? *

Marcar apenas uma oval.

	Not beneficial					Very beneficial
	1	2	3	4	5	

43. If you have any other features to make this part of the tool (Hall of Fame) more accessible to ND, we would be thankful for your suggestions.

For SurveyCircle users, www.surveycircle.com (ignore if you didn't find this survey from there)
The Survey Code is: RFQK-Z6Z6-SCAG-CJPS

Google Formulários