# Integrating digital accessibility in document creation tools

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**Abstract**

Digital content may impose multiple accessibility challenges. These challenges make it harder for individuals with a disability to access and understand information and participate in society. This research aims to improve the creation process of documents, specifically for the Portable Document Format (PDF), to improve the accessibility of documents.

Digital accessibility is the design of content such that everyone can access the information, including individuals with a disability. Currently, only about 2.4% of PDF documents are fully accessible, While government organizations are required by law that their published content is compliant with the Web Content Accessibility Guidelines (WCAG).

To determine the accessibility challenges, we conduct a document analysis and two interviews. For the analysis of the documents, we analyze eighteen documents from four different government organizations. We interviewed a former project manager in digital accessibility and a customer service team leader. Based on these accessibility challenges, we implement a design for a document creation tool that includes nudges to guide the creator in creating accessible documents in public organizations. We demonstrate the document creation tool to consultants and then ask the consultants to evaluate the design based on the user experience, the accessibility measures, and the acceptance of the technology.

The results of the evaluation are positive. The interviewees were positive about the user experience. Specifically, the user-friendliness of the document creation tool is a positive factor for the user experience. The interviewees also believe using the document creation tool would result in better accessible documents. The direct feedback provided by the document creation tool, in combination with the accessibility panel and the feedback on the text difficulties, were the positive factors regarding the accessibility measures. Last, all interviewees agreed they would accept and therefore use the tool.

Thus our research demonstrates that with nudges, digital accessibility could be integrated within a document creation tool to improve the digital accessibility of the documents. The document creation tool guides and supports the creators in creating accessible documents, which improves accessibility Further research includes implementing the document creation tool and evaluating the effects of the accessibility measures.

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# 1 Introduction

As more people rely on digital content to access information and to communicate with each other, it is becoming more important that content is accessible for all people, including persons with a form of disability. In the Netherlands, there are around 2.5 million who have a chronic disability. This includes people who experience visual impairments, mobility limitations, or cognitive or learning disabilities. Apart from permanent disabilities, accessibility is also necessary for individuals with temporary limitations, such as operations that cause vision, hearing, or mobility limitations. But accessible content is also applicable when a screen is not visible due to the sun. Then with a screen reader, the individual can understand and interact with the content [digb].

For Dutch government organizations, Portable Document Format (PDF) documents are one of the most commonly used methods to convey information. PDF documents may present multiple accessibility issues, which make it hard for people with disabilities to access information and participate fully in society. Therefore PDF documents need to be made more accessible. Different measures include providing alternative text to images, tagging PDF documents and using simple language. These measures ensure that more people can access and understand the content of a PDF document.

By the "Temporary decree digital accessibility" (Dutch: Tijdelijk besluit digitale toegankelijkheid), Dutch government organizations are required to ensure that all the content they publish is digitally accessible [vBZeK18]. The law refers to Web Content Accessibility Guidelines (WCAG), which is the international standard for digital accessibility. The WCAG guidelines are a set of technical standards categorized into various levels and principles. Dutch government organizations are required that all their content meets the A and AA standards of the WCAG 2.0 guidelines for web accessibility to comply with the law.

There exist a few tools that automatically check the accessibility of PDF documents. However, there exists no tool that is integrated with the systems that public government officials use to create documents. Therefore, our research will focus on supporting the creation of digitally accessible documents by answering the following research question:

> RQ1. How can digital accessibility be integrated within document creation tool to improve the digital accessibility of documents?

To answer the research question, we will first determine the challenges in creating accessible documents and the reason behind these accessibility challenges. After collecting the causes, we formulate the objectives and create a design for a document creation tool. We demonstrate the document creation tool to consultants. Lastly, different consultants validate the design for the document creation tool.

This research is conducted in collaboration with Mozard. Mozard is an organization that supplies a case management system to different types of government organizations. Through Mozard, we get access to multiple government organizations and their documents and document templates, which we can use for our research.

## 1.1 Thesis overview

In the background, chapter 2, we will explain the definitions and relevant research about digital accessibility. In the background chapter, we also explain about factors behind the acceptance of technology and how to alter behavior with nudges. In the method, chapter 3, we will explain our research approach. We present the design of the document creation tool in chapter 4 and the results of our validation in chapter 5. Next, in chapter 6, we will discuss the results and the implications of digital accessibility. Finally, in chapter 7, we will end with a conclusion.

# 2 Background

In the background, we first discuss what digital accessibility is, what the relevant standards are, and more about PDF accessibility. Second, we discuss the factors behind the acceptance of a technology to determine whether an individual will use our proposed solution. Lastly, we discuss how nudges can alter behaviors and choices to improve digital accessibility.

## 2.1 Digital Accessibility

Digital accessibility ensures that individuals with disabilities can perceive, understand, and interact with digital content. The ISO standard for Ergonomics of human-system interaction defines accessibility as the extent to which individuals with diverse needs, characteristics, and capabilities can use products or services to achieve their goals in specific contexts of use [ISO20]. In essence, digital accessibility refers to the usability of digital content for all individuals [Tur08].

The accessibility of content depends not only on the content itself but also on other factors, such as the authoring tool and the user agent [Hen07]. Authoring tools are software used to create the content, while user agents are responsible for rendering and retrieving the web content for the users. All three factors have their guidelines for creating accessible content. The WCAG standard is the guideline for content, the ATAG standard is the guidelines for the authoring tools, and the UUAG standard applies to the user agent [W3Ca].

### 2.1.1 Content Accessibility guidelines

The World Wide Web Consortium (W3C) has written the Web Content Accessibility Guidelines (WCAG) to promote digital accessibility. W3C aims to keep the web open, accessible, and interoperable by establishing technical standards and guidelines [W3Cb]. The WCAG describes how to make digital content more accessible for people with a form of disability. When content complies with the WCAG, it becomes more accessible, and it improves usability for all individuals [CCRV08].

The WCAG consists of four principles that form the basics of digital accessibility. The first principle, "perceivable", tells that content must be presented in a way that all individuals can perceive the information. The second principle, "operable", means that all individuals must be able to operate the interface. The third principle, "understandable", focuses on that all information and operations are understandable for all individuals. Lastly, the "robust" principle tells that all individuals must be able to access the content through various technologies and user agents. Each WCAG principle consists of multiple guidelines, to make digital content directly accessible to as many individuals as possible. These guidelines contain multiple success criteria, which are the requirements digital content must meet to comply with the guideline. Each success criterion is written as a statement so it can be objectively determined if the content complies with the standard [CCRV08].

The WCAG assigns each success criterion to a specific conformance level. Based on various factors such as if it is essential, achievable, and the impact on the design or function of the content. The three conformance levels in the WCAG are A, AA, and AAA. Conformance level A represents the lowest conformance, where digital content meets all success criteria assigned to level A [CCRV08].

Dutch public government organizations are required by the Temporary decree digital accessibility, that all the content they publish meets the AA level of conformance [vBZeK18].

Compliance with the WCAG does not guarantee that content is accessible and understandable for all individuals. A study found that the WCAG does not cover all accessibility issues in digital content. These issues include a wide gap between related information, crucial information not shown on the top of the page, and color contrast ratios between icon and background [CSS16].

In addition to the WCAG, there is another standard specific to PDF accessibility, the PDF/UA. This standard offers guidance for PDF accessibility by applying the WCAG specifically to PDF documents. Each PDF/UA criterion can be mapped to a WCAG success criterion. The PDF/UA standard only focuses on the accessibility of PDF documents and does not include the general accessibility principles. Consequently, it does not mean that PDF/UA conformance implies conformance with the WCAG and vice versa [Drü12]. A PDF accessibility validator can check a PDF document for compliance with the PDF/UA or the WCAG. It looks for accessibility issues in documents and relates them to a WCAG success criteria or a PDF/UA criteria.

### 2.1.2 PDF accessibility

The portable document format (PDF) is a universal format that guarantees the preservation of layout and can be shared and viewed on different applications and platforms. Adobe Systems initially specified the PDF standard, but since 2008, it has become an open standard described by the ISO 32000 standard [ISO08]. As a result, various tools and applications are now available to modify PDF files. Despite the open standard and the wide use of PDF documents, most PDF documents are not sufficiently accessible. In the scientific field, it is estimated that only 2.4% of published PDF documents are accessible [WCB+21]. Two studies that analyzed PDFs across five accessibility criteria found that all criteria were common accessibility problems. These problems include missing alternative text for figures, incorrectly tagged documents, missing table headers, documents that don't have a default language specified, and incorrect reading order of documents [WCB+21] [LCG+17]. Another study found that missing titles in the metadata were also a common accessibility problem [Nga18].

The accessibility of PDF documents depends on the tools used to create the PDF document. A study on the accessibility of PDFs compared the different tools used to create the PDF. Microsoft Word was the tool with the highest compliance, followed by Adobe Indesign. Latex and Arbortext APP are tools with low compliance [WCB+21]. Compliance was determined by the distribution of satisfied criteria per document creation tool.

The reason why most PDF documents are not accessible is that the creation of an accessible PDF document has several challenges. First, when a PDF document is generated from the document creation tool, metadata about the tagging and the reading order is lost [BBG+16]. Secondly, the creation of digitally accessible documents is a time-consuming job for authors, and it requires specific knowledge about digital accessibility and the tools used to create an accessible document [DSDH14, JRLJ+20, JRJL20]. Third, people find the currently available tools for making PDF accessible are not user-friendly [JRLJ+20].

## 2.2 Acceptance of Technology

The decision of an individual to adopt a new technology is determined by the acceptance of that technology by the potential user. The acceptance of a technology depends on different internal and external factors. Different technology acceptance theories exist, which explain the factors behind the acceptance of an application [San16]. One of these theories is the Technology Acceptance Model 2 (TAM 2).

### 2.2.1 Technological Acceptance Model 2

The Technology Acceptance Model 2 (TAM 2) is derived from the Technology Acceptance Model (TAM). In the TAM model, the perceived usefulness and the perceived ease of use determine the actual use of the system. Therefore those two factors determine if a technology is accepted [DBW89]. Figure 1 shows the TAM model.
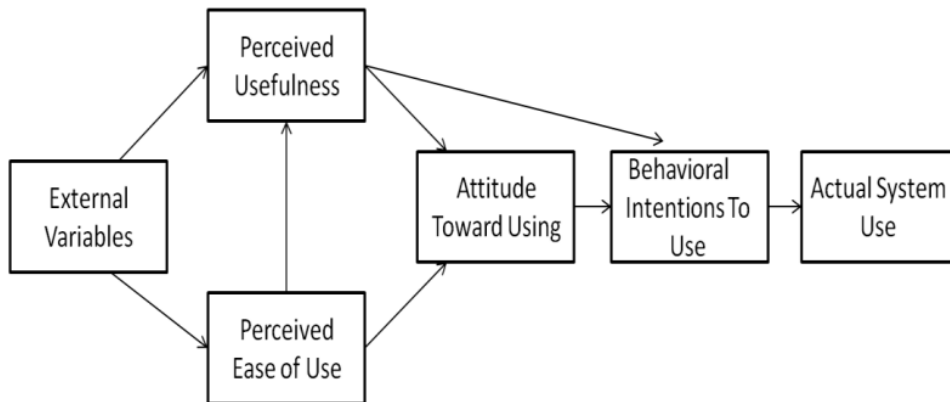


Figure 1: Technology Acceptance Model [DBW89]

Perceived usefulness is the extent to which an individual believes using the application will enhance their job performance. The perceived ease of use means the perceived effort required to use the application [DBW89].

TAM2 is an extension of TAM, integrating social influence and cognitive instrumental processes in the model. The social influence processes consist of subjective norms, voluntariness, and image. Subjective norm refers to an individual's belief in the importance of using the application based on the opinions of important people. Voluntariness is the degree to which adoption of the application is non-mandatory. Image means how the use of an application will enhance the individual's social status. The cognitive instrumental processes consist of job relevance, output quality, result demonstrability, and perceived ease of use. Job relevance is the belief that the application applies to the individual's job. Output quality describes how well an application performs the tasks. Result demonstrability is how well the results of using an application can be demonstrated and communicated. The perceived ease of use in the TAM2 model still has the same meaning as in TAM [VD00].

Figure 2 illustrates TAM 2, which demonstrates how social influence and cognitive instrumental processes affect the usage of an application. All cognitive instrumental processes have a positive

effect on perceived usefulness. Social influence can impact usage behavior through the intention to use or perceived usefulness. Impact on the intention to use appears when the usage of the application is mandatory. In such cases, individuals decide to use an application based on the belief that an important person thinks they should, even if the individual does not prefer it. When usage is not mandatory, the subjective norm influences the perceived usefulness. An individual's social image positively affects the use of an application by improving productivity or influence over the subjective norm [Ven99].
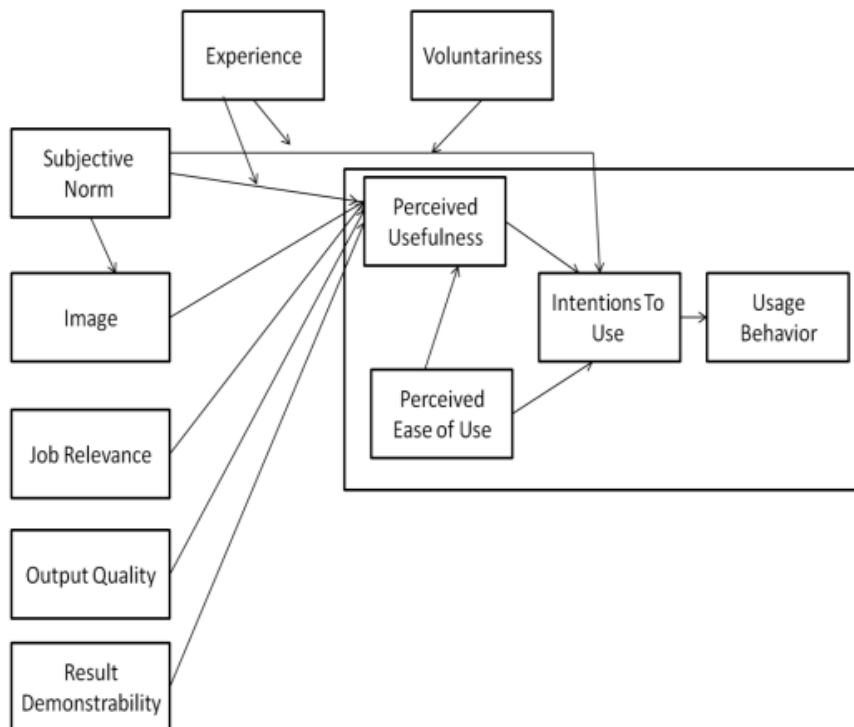


Figure 2: Technology Acceptance Model 2 [VD00]

## 2.3 Nudges

The individual's decision depends on different factors and can be influenced by changing the features of the environment in which the individuals make a decision. These changes are called interventions. Nudges can subtly change these features to alter individuals' behavior predictably by exploiting cognitive processes such as biases and heuristics. An intervention qualifies as a nudge when the intervention does not forbid or remove any choice the individual had before the nudge, and no choice should cost more in terms of time, effort or in financial terms [ZR21].

To understand how nudges work, we first need to understand how individuals think and how they make decisions. Thinking and decision-making consist of two different systems, System 1 and System 2. System 1 is the system for automatic, intuitive, and fast cognitive processes, relying on heuristics, patterns, emotions, and past experiences to make quick judgments and decisions.

System 2 is for the analytical, conscious, controlled, and slow cognitive processes, using logical, rational, and critical thinking for decision-making [Kah15].

### 2.3.1 Type of nudges

There are different types of nudges, which we can categorize based on the cognitive process the nudge uses. The first type of nudge engages System 1 [BG15]. These nudges aim to change an individual's behavior by invoking quick and intuitive reactions. Nudges can engage System 1 with various methods. First, nudges can arouse emotions to influence the decision-making process. A nudge can frame the benefits of a desired choice to make it seem more positive. Second, nudges can simplify decision-making. System 1 prefers the processes or options that require less effort to implement. A nudge can therefore reduce the effort or simplify the choice to influence the decision-making process. Last, nudges can engage System 1 by using biases to influence an individual's decision [BK20] [BG15].

The second type of nudge engages System 2. These nudges aim to activate System 2 rather than System 1 to change an individual's behavior. There are various methods for engaging System 2 with nudges, including nudges that create opportunities for reflection, prompt planning, inspire broader thinking, increase accountability, use reminders, encouraging joint evaluation and disconfirming evidence [BG15]. These nudges aim to activate System 2 so that individuals can rely on their analytical, rational, and slower cognitive processes for making better decisions instead of relying on their automatic, intuitive, and fast cognitive processes [BG15].

The last category of nudges bypasses System 1 and System 2. These nudges take action based on input from individuals. Therefore, there is no need to engage either System 1 or System 2. There are two methods for bypassing both systems. First, nudges can set a default option. Many individuals accept the default options without using either System 1 or System 2 to consider their options [BK20]. A nudge can help individuals to opt for the best available choice by setting a default. Secondly, a nudge can make automatic adjustments to account for flaws in System 1 and System 2 thinking. Because of cognitive biases in both systems, nudges can influence the outcome of an individual's action by adjusting for these biases [BG15].

### 2.3.2 Implementing nudges

Not all nudges are effective for all situations. The effectiveness of a nudge depends on the goals of the decision maker, the characteristics of the decision maker, and the decision context [JSD+12]. Lindhout and Reneirs [LR17] propose a logical sequence of six steps for implementing a nudge. The process begins with assessing the current situation and behavior to determine the improvement areas. The second step is understanding the factors influencing an individual's intentions and behaviors. The third step is to select a nudge type based on the current situation and the factors influencing the behavior. Next is designing, constructing, and pre-testing the nudge. As a baseline for comparison observing the current individual behavior is necessary. Step five is the implementation of the nudge in the process and observing the individual's behavior to validate the effectiveness. Finally, the last step is to evaluate the effectiveness of the nudge and the development process [LR17].

# 3 Method

Our research aims to improve the digital accessibility of documents by increasing awareness about digital accessibility and guiding public government officials in creating accessible documents. The research follows the Design Science Research Process (DSRP) to answer the research question. The DSRP process consists of six steps. The first step is the problem identification and motivation for the research. The second step is the objective of a solution. The third step is the design and development of a solution. Fourth is the demonstration of the solution to relevant stakeholders. Fifth is the evaluation of the solution. The last step is the communication of the results of the research, which can be in the form of a research paper [PTG+20].

To find the objectives of the solution, we first determine what the current accessibility challenges are in creating documents. Based on these objectives, we create a design for a document creation tool that supports government officials in creating accessible documents. The design is then demonstrated to consultants. The results of these interviews are used for the evaluation. Figure 3 shows this process.
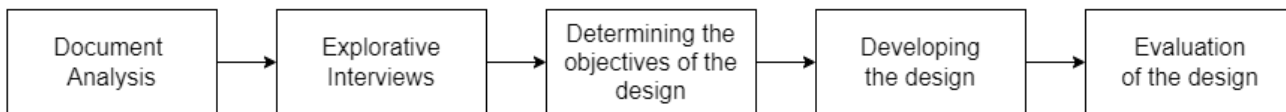
Figure 3: The research process we use for our research

## 3.1 Finding current accessibility challenges

To determine the biggest challenges in making a PDF accessible for government officials, a document analysis and interviews are performed. For the document analysis, we used eighteen documents from four different government organizations. We gathered 4-5 templates from each organization's document creation tool, filled them with sample data, downloaded them as a Word file, and saved them as a PDF. All PDF files are then checked for accessibility problems with PDFchecker.nl and PAC 2021. We use PDFchecker because it is an open-source tool subsidized by the Dutch Ministry of the Interior and Kingdom Relations [Ple22]. The Dutch government recommends using PDFchecker as a tool to ensure digital accessibility [Diga]. We use PAC 2021 to validate the results of the PDFchecker application.

To analyze the accessibility of the PDF documents, we categorized the issues into four groups: metadata, tables, lists, and missing alternative text. We then calculated per category the number of documents that had an issue, both overall and per organization. With the results of issues per category, we could better identify the specific areas where most accessibility issues exist.

After analyzing the documents, we conducted two explorative semi-structured interviews to get more information about the reasons behind the accessibility issues. In the interview, we asked

open-ended questions about three main topics. The first topics were the general questions about the role of the interviewee and the organization. The second topic was about the WCAG and discussed the challenges for the organization per category. The third topic addressed other accessibility challenges and the underlying causes of these challenges.

One participant is a former project manager in a municipality. The project was about improving the digital accessibility in the organization. The other participant in the interview is a customer service team leader for an organization that is a contractual partner of a municipality, the organization does some communication directly with citizens.

## 3.2 Creation of the design

After conducting a document analysis and the interviews, we determine the accessibility objectives for the document creation tool using existing literature and the results from the document analysis and the interviews. We combine all inputs from these three sources in one list. Based on the causes behind the accessibility problems, we formulate the accessibility objectives. The design also has functional requirements. Research by Lee [Lee23] identifies these requirements. To gather these requirements, the study analyzed the features of the existing solutions. Then questionnaires were sent to the organization and its customers to determine which features should be included in the minimum viable product.

The most important requirement is the possibility to add dynamic data to the template, which could be via a case, using questions, or a date. Also, the possibility to add components and decision trees are important features.

We create a prototype for the design using Figma, a design application for prototypes. First, a prototype is made with only the functional requirements. Then nudges are added in the design to support the creator in creating accessible documents and to reach the accessibility objectives. With Figma, the prototype is made interactive. Therefore we can better demonstrate the document creation tool to interviewees and give them a better understanding of the document creation tool. The design does not consist of all the functional requirements that were specified in the objective. Because the goal is to understand and determine the impact of the accessibility measures, not to create a complete design for a document creation tool.

## 3.3 Evaluation of the design

We conducted four structured interviews with different consultants to evaluate and validate the design for the document creation tool that supports the creation of accessible documents. All consultants have experience with other document creation tools with different roles, ranging from functional maintainer to project manager.

The interviews consist of four parts. Appendix B shows the questions that were asked for the validation of the document creation tool. In the first part, we demonstrate the document creation tool using a prototype in Figma. In this part, we explain all features and the interviewee can ask questions regarding the design. The goal is to ensure that the design of the document creation

tool is understandable for the interviewee so they can answer the questions. In the second part, we ask questions about the user experience to get their opinion about the design. The questions are about their first impression, suggestions for improvements, and questions about usability. The third part is about the accessibility measures in the document creation tool. The goal is to determine if the use of the tool will result in better accessible documents. Questions are about the current effectiveness of the measures and suggestions for further improvement. The last part of the interview is about the technology acceptance model to determine the acceptance of the document creation tool. Questions are about the different factors in the TAM2 that influence usage behavior. However, we do not ask questions about the "image" factor because the consultants are not the actual users and can not provide insight if the document creation tool enhances the user's social status.

After the interviews, we analyze the answers to the user experience, the accessibility questions, and the questions about the technology acceptance model. The user experience questions are formulated so the response could be either positive or negative. Based on these answers we can determine if the respondents are either in favor or against the document creation tool. For the accessibility questions, we use the key points of the answers to determine if the usage of the document creation tool will result in better accessible documents and to identify improvement areas. The questions about the technology acceptance model are formulated so that the interviewee could either agree or disagree with the statement. If the interviewee agrees with a statement it means that the factor positively influences usage behavior. Thus we can determine with the answers if the design is accepted and if they will use the document creation tool.

# 4   Design

Before creating a design, we first determine the objectives of the design with document analysis, interviews, and past research. Last, we explain the design and the accessibility measures in the design.

## 4.1   Input for the design

Section 2.1.2 discuss the reasons why PDF documents are not accessible. One of the reasons is that creating an accessible document is a time-consuming job, which requires specific knowledge about digital accessibility [DSDH14, JRLJ$^+$20, JRJL20]. Second, the authoring tool to create the documents loses metadata and is, therefore, not accessible [BBG$^+$16]. Last, people find the current tools available to make PDF accessible not user-friendly [JRLJ$^+$20].

Apart from the challenges in the literature, we also perform a document analysis and two interviews with government officials. All information serves as input for the design.

### 4.1.1   Document analysis

Out of the 18 documents we analyzed, no document was fully accessible according to PDFchecker and PDF Accessibility Checker (PAC) 2021. Table 1 shows the results of the document analysis. On average, the accessibility score per organization in PDFchecker was 66%. The first two organizations scored the highest, with an average of 76%, while the third organization scored the lowest, with an average of 45%.

| Category | organization 1 | organization 2 | organization 3 | organization 4 | Total |
|---|---|---|---|---|---|
| Title in metadata | 5 | 5 | 4 | 4 | 18 |
| Alternative text | 3 | 2 | 4 | 1 | 10 |
| Tables | 1 | 3 | 4 | 3 | 11 |
| Lists | 1 | 2 | 2 | 0 | 5 |
| Accessibility score | 76% | 76% | 45% | 65% | 66% |

Table 1: Results of document analysis. The table shows the amount of documents per organization where a certain accessibility issue persists. The last row shows the average score given by PDFchecker.

None of the documents had a title specified in the document's metadata. The title is the first thing read by a screen reader. Without a title in the metadata, screen readers can not read it, which can lead to accessibility issues. Additionally, ten documents had missing alternative text for images or links. An alternative text describes the content within images or links. Without alternative text, individuals with visual impairments or with screen readers can not understand the information in images or links. Furthermore, eleven documents had issues with the structure of the tables. These problems were due to not correctly tagging the tables in the PDF document. Incorrectly tagging tables in combination with merged cells or headers and subcells that are not related to each other could result in an incorrect interpretation of the table by the screen reader. As a result, individuals who use screen readers may encounter problems understanding the information within

a table. Lastly, five documents had accessibility issues where a list was not tagged as a list. This issue can cause problems with navigating and understanding lists for individuals who use assistive technologies.

### 4.1.2 Interviews

We did two interviews with government officials about their experiences with digital accessibility, to better understand the reason behind the not fully accessible documents. Both interviewees mentioned the lack of awareness within their organization as a factor for the lack of accessible documents. One interviewee said that the organization primarily focuses on the understandability of the text and uses the corporate identity, so the fonts or colors can not impose an accessibility issue. Apart from these aspects, there was no attention to the accessibility of the created documents.

Another factor both interviewees mentioned was the lack of knowledge about digital accessibility. One interviewee said that public government officials were unfamiliar with the importance of creating accessible documents or the reason behind accessibility requirements. Although the organization used a tool to check documents for accessibility issues, the tool did not mention how to solve the accessibility problems. The other interviewee also noted that an accessibility checker should show suggestions to solve the identified accessibility issues.

Additionally, one interviewee mentioned the lack of adoption of writing digital accessibility documents within the organization. The public government officials responsible for creating the documents did not perceive any benefits in creating accessible documents, while it requires additional effort on their part.

## 4.2 Objectives of the design

Table 2 shows the causes for the lack of accessible documents from the literature and the interviews. We classify the problems from the document analysis into two categories. First, the non-technical causes for the issues require a small effort, such as alternative text, lists, and metadata. Second, solving the accessibility issues for tables is more complex and could be because of a lack of technical knowledge.

| Accessibility causes | in design |
|---|---|
| Creating accessible documents is time-consuming | X |
| Creating accessible documents requires knowledge about digital accessibility | X |
| Authoring tool loses metadata when converting document to PDF | |
| Lack of awareness about digital accessibility | X |
| Lack of adoption in an organization | X |
| Lack of user-friendly tools to create an accessible document | X |
| Technical knowledge is required to make a PDF accessible | |

Table 2: Table with the causes behind the accessibility issues, and if the causes are incorporated in the design

The design aims to create a document creation tool that supports officials in creating accessible documents. The first objective of the document creation tool is to raise awareness about digital accessibility. If the creator is not aware of digital accessibility, the other accessibility measures would be irrelevant. The second objective is to make a user-friendly document creation tool. The tool does this by identifying possible accessibility issues and assisting government officials with resolving accessibility problems. The added benefits of making the application user-friendly are that it makes the creation of accessible documents less time-consuming, it lowers the amount of knowledge required to create an accessible document, and it makes the adoption of the document creation tool and the accessibility measures easier.

The interventions used in the tool to enhance accessibility are in the form of nudges. Therefore, government officials are not obligated to comply with the accessibility objectives. The objective is to support individuals in creating accessible documents by offering suggestions and recommendations rather than imposing mandatory requirements.

In the design, there are also a few functional requirements. These requirements are features in the document creation tool and are specified in Appendix A. These requirements are gathered in research by Lee [Lee23]. The application should also be web-based and have the same appearance as Word so public government officials can adopt the tool faster.

## 4.3   Explanation of the design

The document creation tool is designed to resemble a Word editor and consists of four main sections as seen in Figure 4. The first section is the middle area which serves as the workspace, where the document is displayed, and the user can type and edit the content. The second section is the toolbar located at the top of the page. The toolbar provides the users with the necessary tools and options to create the document.

The right section consists of an accessibility tab and a navigation tab. The accessibility tab provides an overview of accessibility problems and suggestions in the document. The navigation panel gives an overview of all the headings used in the document. The left area consists of three tabs to create templates. The data tab is to add placeholders in the document. The second tab is to add and alter components in the template. With the third tab, the user can start a preview of the template. The right section is necessary to create templates out of the documents.

### 4.3.1   Accessibility measures

The document creation tool consists of a few nudges to support the creation of accessible documents. Figure 5 gives an overview of the nudges in the tool. One of these measures is the accessibility panel which consists of two parts. One part is to detect and solve accessibility problems, and the other part is a checklist that identifies potential accessibility issues in the document. The checklist is for problems the document creation tool can not recognize but often appears in a text. An item appears in the checklist when the creator does certain actions. When this happens, the creator can check it and mark it as complete. But, when the action repeats, the checklist item reappears.
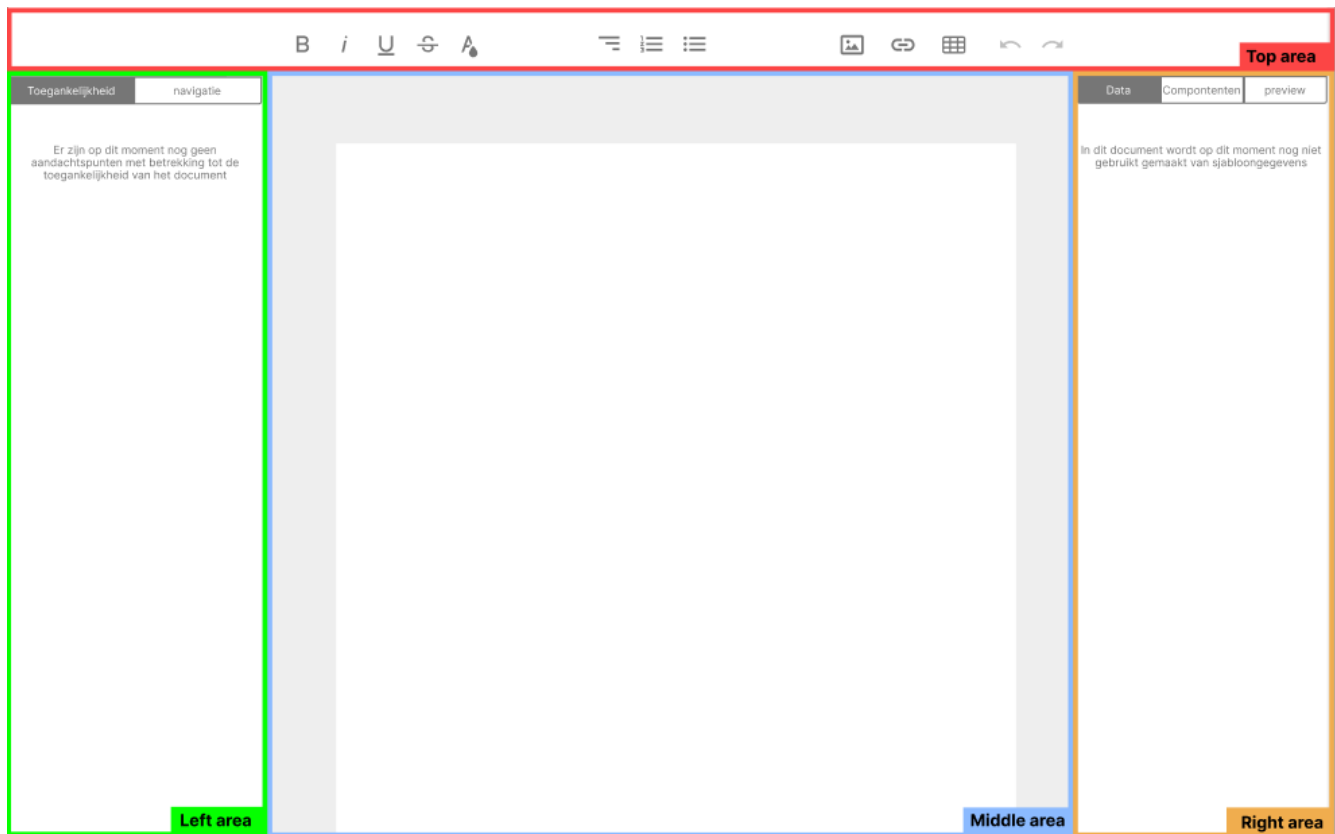
Figure 4: Overview of the different areas in the tool

There are a few types of nudges in the accessibility panel. The first nudge is the prominent place of the accessibility panel in the document creation tool, intending to make the accessibility panel more noticeable and drawing attention to the accessibility panel. Therefore the creator can constantly see the accessibility issues while creating the document. The second nudge is a simplification to make the creation of accessible documents seem easier. Instead of one process for making documents accessible, the process is split into multiple actions. The actions consist of a description that describes why it is an accessibility problem and a suggestion of how to solve the accessibility issues. In addition to the accessibility panel, other nudges are implemented to improve the accessibility of documents. First, creators receive feedback on the text's difficulty per paragraph beside the text. Different colors and a language level indicate the difficulty of the text. Green means an appropriate level, while orange indicates that a paragraph may be too difficult. Second, the user gets notifications above the document when other accessibility issues appear. Both are nudges that give feedback to the creator.

The last nudge in the document creation tool is a default option that is set so the application can support the creation of accessible documents. When the option is disabled, the creator does not receive feedback about the document's accessibility. The user can turn off the option, so the accessibility guidance is non-mandatory. This nudge can be seen in Figure 6
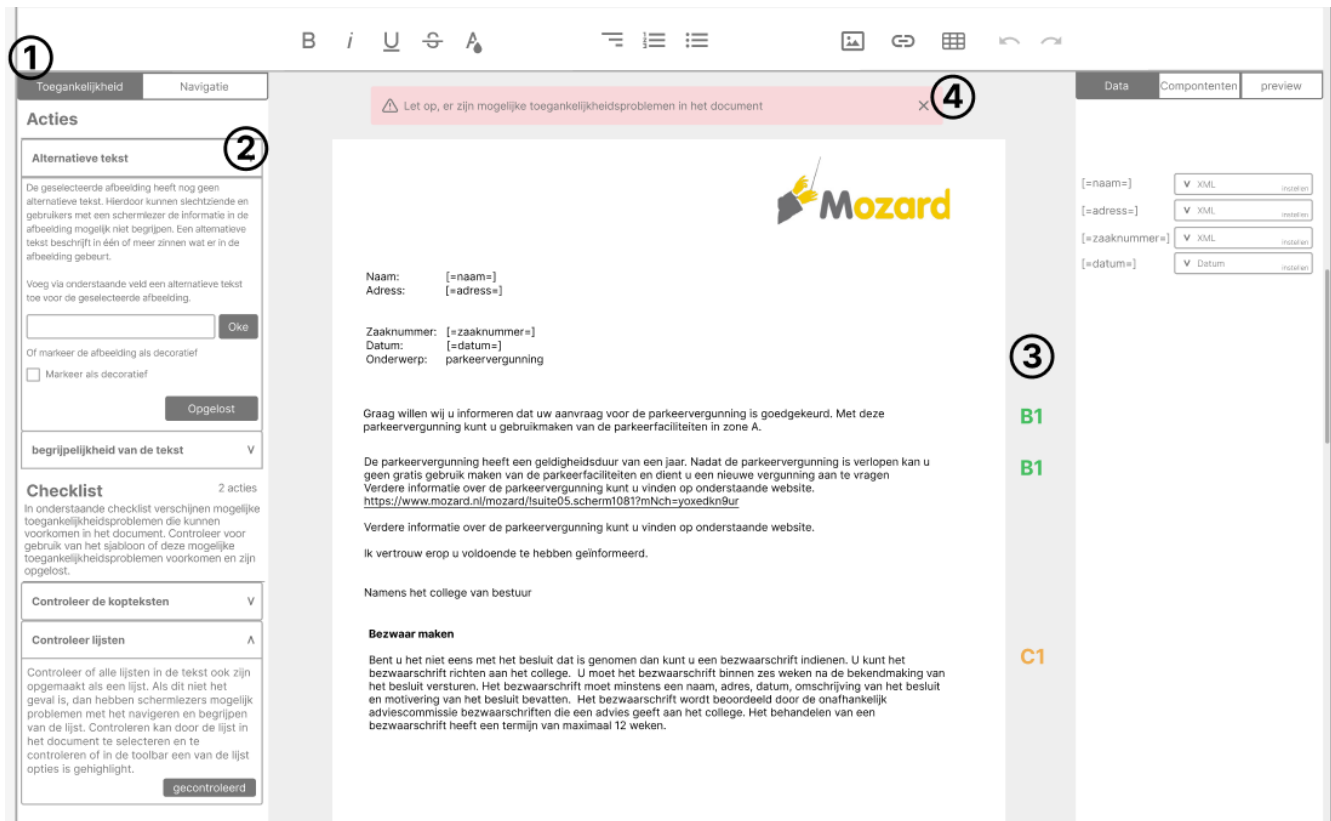
14

Figure 5: Overview of the accessibility measures in the tool. Measure 1 is the prominent placing of the accessibility panel. Measure 2 is the simplification of the accessibility solving process and measure 3 and 4 give feedback about text difficulty and other accessibility problems.



Figure 6: The default option enabled when creating a document

# 5 Result

The prototype created in section 4 is demonstrated to four consultants. The results are split into user experience, accessibility, and the technology acceptance of the model.

## 5.1 Results of the expected user experience

Table 3 shows the opinion of the respondents on different user experience factors. The table shows a positive attitude towards the prototype for the document creation tool.

| User experience factors | Interviewee 1 | Interviewee 2 | Interviewee 3 | Interviewee 4 |
|---|---|---|---|---|
| First impression | Positive | Positive | Positive | Positive |
| User friendliness | Positive | Positive | Positive | Positive |
| Usability | Neutral | Positive | Neutral | Positive |
| Intention to use | Positive | Positive | Positive | Positive |

Table 3: Results of the user experience questions, table shows if interviewee is in favor, against or neutral against an user experience factor

When we asked the interviewees about their first impression of the document creation tool, three out of four interviewees expressed that user-friendliness was a positive aspect of the design. However, one respondent raised a concern that accessibility should not dominate the design because the creation of documents is the primary goal of creators, not accessibility. Having all tools in one overview, the minimalist design, and the guidance in creating accessibility documents were the factors that contributed to a user-friendly application, according to the interviewees. Two respondents had a neutral opinion about the usability of the design. They believe some necessary features to create templates were missing in the prototype and could not assess the usability. The other two interviewees think the prototype would be sufficient for simple templates. All interviewees would use the document creation tool.

In addition to the user experience factors in Table 3, we asked the interviewees to compare the prototype with existing solutions, what they would change in the prototype, and what the positive and negative aspects are in the design.

All interviewees agreed that the prototype was clear and better organized than the existing solutions they have experience with. Two interviewees find the accessibility features of the prototype better than those in current solutions. Other solutions did not have an accessibility feature, or the feature was not user-friendly. On changing the prototype, one interviewee would alter how the checklist works, and one would add more clarification to the different tabs. The other two interviewees would not make any changes to the design. The interviewees mentioned several positive aspects of the prototype, such as user-friendliness, the use of an accessibility panel, feedback on the text difficulty, and the preview option. The interviewees also mentioned several negative aspects. One interviewee mentioned that the combination of the right and left areas resulted in too much information on the screen. The interviewee suggested that the right area should be collapsible. Another negative aspect was that the accessibility panel takes too much space in the design.

## 5.2 Results of the accessibility measures

Overall all four interviewees believe using the prototype would result in more accessible documents. Two interviewees specified that direct feedback is a positive factor in creating accessible documents. When asked what accessibility measures had a positive impact, all four interviewees mentioned the accessibility panel. Three interviewees believed that the feedback about the text difficulty had a positive effect. One interviewee thought the notifications had a positive impact, while another interviewee did not believe that the notifications provide added value in creating accessible documents.

All interviewees gave feedback on the clarity of the descriptions in the accessibility panel. These descriptions (in Dutch) are listed in Appendix C. For the alternative text, all interviewees found it clear, but two recommended adding an explanation of what decorative means and the effect of marking an image as decorative. Two interviewees thought that the description of headings was clear, while one suggested an additional explanation on how to add headings in the document. Another interviewee had difficulty interpreting whether all documents should contain headings or if the checklist item should only be checked when the document uses headings. All four interviewees believed that the description of the lists was clear, but two recommended adding the icons of lists for extra clarity.

All interviewees mentioned that improvements are needed to the text difficulty for better clarity. One interviewee suggested explaining what text difficulty and language levels are. One recommended adding a link to a tool where the user gets more feedback on the text difficulty, and two recommended adding an explanation of how to rewrite the text. One interviewee acknowledged the challenges of finding the right balance between too much information and too little information in the descriptions and suggested that the functional maintainers of an organization should be able to modify the descriptions.

When asking the interviewees what could be added to the design to improve awareness about digital accessibility, two interviewees suggested adding a warning when saving a document that is not accessible. One interviewee recommended including a link to an accessibility website so the creator can read more about digital accessibility.

The interviewees also gave feedback to improve the guidance in creating accessible documents. One interviewee suggested adding a screen reader in the design so the creator can understand how accessible and understandable the document is for people with a screen reader. Other suggestions were making the text difficulty more specific and adding more explanations in the design about digital accessibility and accessibility problems. Another interviewee remarked on the importance of directly linking every action in the accessibility panel to an issue in the document.

## 5.3 Results of the technology acceptance

Table 4 shows the results of the technology acceptance. The TAM2 model consists of cognitive instrumental processes and social influence processes. The cognitive processes include job relevance, output quality, result demonstrability, and perceived ease of use. All interviewees agree that the document creation tool is relevant for template creators, that the output of the document creation

tool is good enough, that it seems easy to use, and that the use of the document creation tool will result in accessible documents which are demonstratable.

| TAM2 factors | Interviewee 1 | Interviewee 2 | Interviewee 3 | Interviewee 4 |
|---|---|---|---|---|
| **Job relevance** | Agree | Agree | Agree | Agree |
| **Output quality** | Agree | Agree | Agree | Agree |
| **Result demonstrability** | Agree | Agree | Agree | Agree |
| **Perceived ease of use** | Agree | Agree | Agree | Agree |
| **Social norm** | Agree | Agree | Agree | Dependent |
| **Voluntariness** | Mandatory | Mandatory | Mandatory | Voluntarily |

Table 4: Results of the factors in the TAM2, interviewees could indicate if they agree with the factors that positively affect usage

The social influence processes include the social norm and voluntariness. Three interviewees think that the important people in an organization will recommend using the tool and that the use would be mandatory. However, one interviewee believes it depends on the organization's policy and that the use of the document creation tool would be voluntary.

# 6 Discussion

The results show that the interviewees believe they would have a positive user experience when creating a document. The user-friendliness of the document creation tool was a positive aspect regarding the user experience, especially in comparison with other tools. Half of the interviewees also believe they could create templates and documents using the document creation tool. The design is thus effective in providing a positive user experience.

Regarding accessibility, the results show that implementing the design for the document creation tool would result in better accessible documents. Specifically, the direct feedback about the accessibility would positively impact the accessibility, according to the interviewees. The interviewees believe that the accessibility panel and feedback on the text difficulty were the most impactful accessibility features. However, clearer descriptions in the accessibility panels could further improve the accessibility of the documents. When modifying these descriptions for the accessibility tool, it is important to find a balance between too much and too little information. Too much information may overwhelm the creator and could decrease the user experience, while too little information may result in a lack of understanding for the creator about the accessibility issues. The required information also varies depending on the user's knowledge and preferences.

The results of the technology acceptance show that the interviewee will accept the document creation tool and therefore intends to use it. All interviewees agreed that all cognitive instrumental process factors had positively impacted the perceived usefulness, which will affect the usage behavior. Additionally, three out of the four interviewees think important people in an organization would recommend the tool. If the document creation tool is mandatory, it would influence the intention to use it and the usage behavior.

Apart from the clarifications in the description, there are other improvement areas. First, by providing notifications when the creator saves a document that is not accessible, we could improve awareness about digital accessibility. Furthermore, making the right area collapsible would reduce the information visible in the document creation tool. Therefore some creators would not be overwhelmed by the amount of information on the screen. Lastly, other accessibility measures can be added to the document creation tool, such as a preview for a screen reader.

## 6.1 Limitations

There are a few limitations in the study. First, to validate the design for the document creation tool, the consultants were asked open-ended questions. Therefore to process the results, we had to interpret the results. Which could result in the interpretation would be too positive compared with the answers from the interviewees. Second, four consultants evaluated the design. It would be better to interview different stakeholders. Including the stakeholders who create the templates, individuals who will use the template, and management for more robust results.

Last, the document creation tool can not prevent all accessibility issues. Accessibility consists of three parts, the content, the authoring tool, and the user agent. Our research only focuses on the content itself. Therefore accessibility issues could exist in the document, such as when the authoring

tool loses metadata when converting the created document to PDF. In addition, the document creation tool only checks the document for a few common accessibility issues, which could result that the created document is not fully accessible.

## 6.2   Generalizability

The results are generalizable and could be used for other research. First, in the document analysis phase, the identified accessibility issues would likely exist in other fields. Therefore, these problems can serve as a starting point for research in various domains.

Second, in the explorative interviews, we mention a lack of awareness as one of the reasons for less accessible documents. We expect that other organizations that are not obligated to comply with the accessibility law also lack awareness about digital accessibility. The finding could be useful for other research that aims to improve the accessibility of digital content, not just limited to PDF documents.

Last, for the design and the validation of it, we learned that with nudges, we could guide and support creators in creating better accessible documents. Specifically, nudges that provide direct feedback on accessibility issues and integrate a prominent accessibility panel. Also, simplification help in supporting creators in making accessible documents. Other research could incorporate the nudges in other document creation tools or platforms for generating various types of digital content.

# 7 Conclusion

In conclusion, our research aims to improve the digital accessibility of PDF documents by implementing nudges within a document creation tool. These nudges guide the creator by improving awareness about digital and supporting the creation of better accessible documents. The research question for this thesis was: How can digital accessibility be integrated within a document creation tool to improve the digital accessibility of documents?

The results show that our document creation tool would result in better accessible documents. Furthermore, the design provides a positive user experience with a more user-friendly interface compared with current solutions. Lastly, the tool is accepted by consultants.

Thus our research demonstrates that with the use of nudges in a document creation tool, we can guide and support the creator in creating accessible documents. With these nudges, we can integrate digital accessibility within document creation tools to improve the digital accessibility of the documents. Direct feedback and prominent placement of the accessibility panel will assist the creators in improving the accessibility of documents.

This research builds further on past digital accessibility research by introducing nudges in the creation process. These nudges guide the creators in creating accessible documents. These nudges could also be implemented in other document creation tools, website development, and other forms of digital content. The nudges result in more accessible content, which enables that individuals with a disability, such as a visual impairment, learning difficulties, or mobility limitations, could access and understand the information to participate in society. Further research could involve implementing the nudges in a document creation tool and evaluating the impact of the accessibility measures. Additionally, determining the individual effect of these nudges and implementing additional nudges could be a possibility for further research.

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# A    Features for the document creation tool

| | | |
|---|---|---|
| **F1** | Version control for the documents and templates | x |
| **F2** | Check-in and check-out for documents and template | x |
| **F3** | Central Storage | |
| **F4** | Intelligent search functionality | |
| **F5** | At least one Gigabyte support for files | |
| **F6** | Authorisation system with different roles | x |
| **F7** | Insight to quantitative information | |
| **F8** | Math module in the template | |
| **F9** | Digital signature | x |
| **F10** | Possibility to import case details and use them in templates | x |
| **F11** | Decision trees (Possibility to show questions based on an answer) | x |
| **F12** | Can add metadata to templates or documents | x |
| **F13** | Components (Possibility to reuse sets of template features in multiple templates | x |
| **F14** | Group function (Function to add rows to tables) | x |
| **F15** | Text question (a question where the answer consists out of text) | x |
| **F16** | Selection question (a question where the answer consists out of a choice from a list) | x |
| **F17** | Date question (a question where the answer consists out of a date) | x |

Table 5: Features for document creation tool, An x after the feature indicates that the feature should be included in a minimum viable product [Lee23]

# B    Questions for the validation interview (Dutch)

**User Experience Questions**

- Wat is je eerste indruk van het prototype

- Hoe gebruiksvriendelijk is het prototype.

- Denk je dat het prototype geschikt is voor het doel (sjablonen maken)

- Hoe vergelijk je de prototype met de bestaande oplossingen

- Zijn er bepaalde aspecten die positief of negatief opvallen

- Zijn er bepaalde veranderingen de je zou doen om de applicatie te verbeteren

- Vindt je dat de tool gebruikt moet worden

**Accessibility questions**

- Heb je het gevoel dat je met dit prototype betere digitaal toegankelijke documenten kan creëren in vergelijking met de bestaande oplossingen

- Welke interventies vielen op vond je dit een toegevoegde waarde hebben

- In het toegankelijkheidspaneel wordt er per eis opgeschreven wat er gedaan moet worden wat is je mening over deze beschrijving

- Op welke punten kan het ontwerp verbeterd worden om de bewustzijn over digitale toegankelijkheid te verbeteren

- Op welke punten kan het ontwerp verbeterd worden om de gebruikers beter te helpen in het creëren van digitale toegankelijke documenten

**Technology Acceptance Questions**

- Job Relevance: De document creatie tool is geschikt voor het maken van documenten

- Output Quality: De kwaliteit van de document creatie tool is naar verwachting

- Result demonstrability: De document creatie tool zal helpen bij het maken van toegankelijke documenten en dat is ook aantoonbaar

- Perceived ease of use: De applicatie lijkt gemakkelijk in gebruik

- Social norm: Dit is een tool die aangeraden zou worden door belangrijke personen in de organisatie

- Voluntariness: Zal dit een verplichte applicatie worden binnen een organisatie of vrijwillig

# C  Text in the document creation tool (Dutch)

**Alternatieve tekst**

De geselecteerde afbeelding heeft nog geen alternatieve tekst. Hierdoor kunnen slechtziende en gebruikers met een schermlezer de informatie in de afbeelding mogelijk niet begrijpen. Een alternatieve tekst beschrijft in één of meer zinnen wat er in de afbeelding gebeurt.

Voeg via onderstaande veld een alternatieve tekst toe voor de geselecteerde afbeelding.

Of markeer de afbeelding als decoratief

**Kopteksten**

Controleer of de tekst gebruikt maakt van kopteksten en of deze ook zijn opgemaakt als koptekst. Deze kopteksten dienen als navigatie voor slechtziende en gebruikers met een schermlezer. Een koptekst alleen dikgedrukt maken is niet voldoende.

**Lijsten**

Controleer of alle lijsten in de tekst ook zijn opgemaakt als een lijst. Als dit niet het geval is, dan hebben schermlezers mogelijk problemen met het navigeren en begrijpen van de lijst. Controleren kan door de lijst in het document te selecteren en te controleren of in de toolbar een van de lijst opties is gehighlight.

**Taal niveau**

In het document is er nog een paragraaf die C1 als taalniveau heeft. Hierdoor kunnen laaggeletterde de informatie moeilijk begrijpen. Herschrijf deze paragraaf zodat de informatie voor iedereen begrijpbaar is.