Designing Smart Agents to Sustain Professional Painting Practices
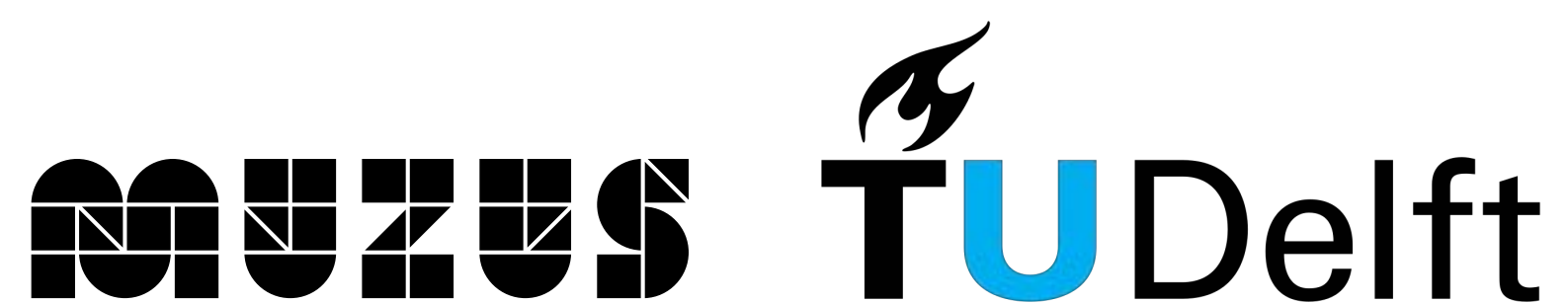
MUZUS   TUDelft

Stichting Uitvoeringsregelingen SAG
Schilders-, Afwerkings- & Glaszetbedrijf

Table of Contents

About the Project Team

Researchers of the TU Delft and designers of social design agency Muzus join forces to take a peek into the future of painters for SUSAG.

SUSAG
SUSAG is the Dutch Foundation for Implementation Regulations for the Painting, Finishing, Property Maintenance and Glazing Industries (Stichting Uitvoeringsregelingen voor het Schilders-, Afwerkings-, Vastgoedonderhoud- en Glaszetbedrijf). The SUSAG Foundation's purpose is to provide support for employers and employees in the fields of sustainable employability, compliance and enforcement, collective accident insurance and organizational leave.
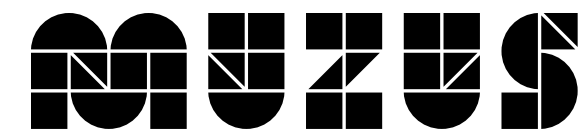
MUZUS
Muzus explores the needs and experiences of painters with contextmapping, and concludes the research process by analysing the opportunities of the various concepts that were produced.
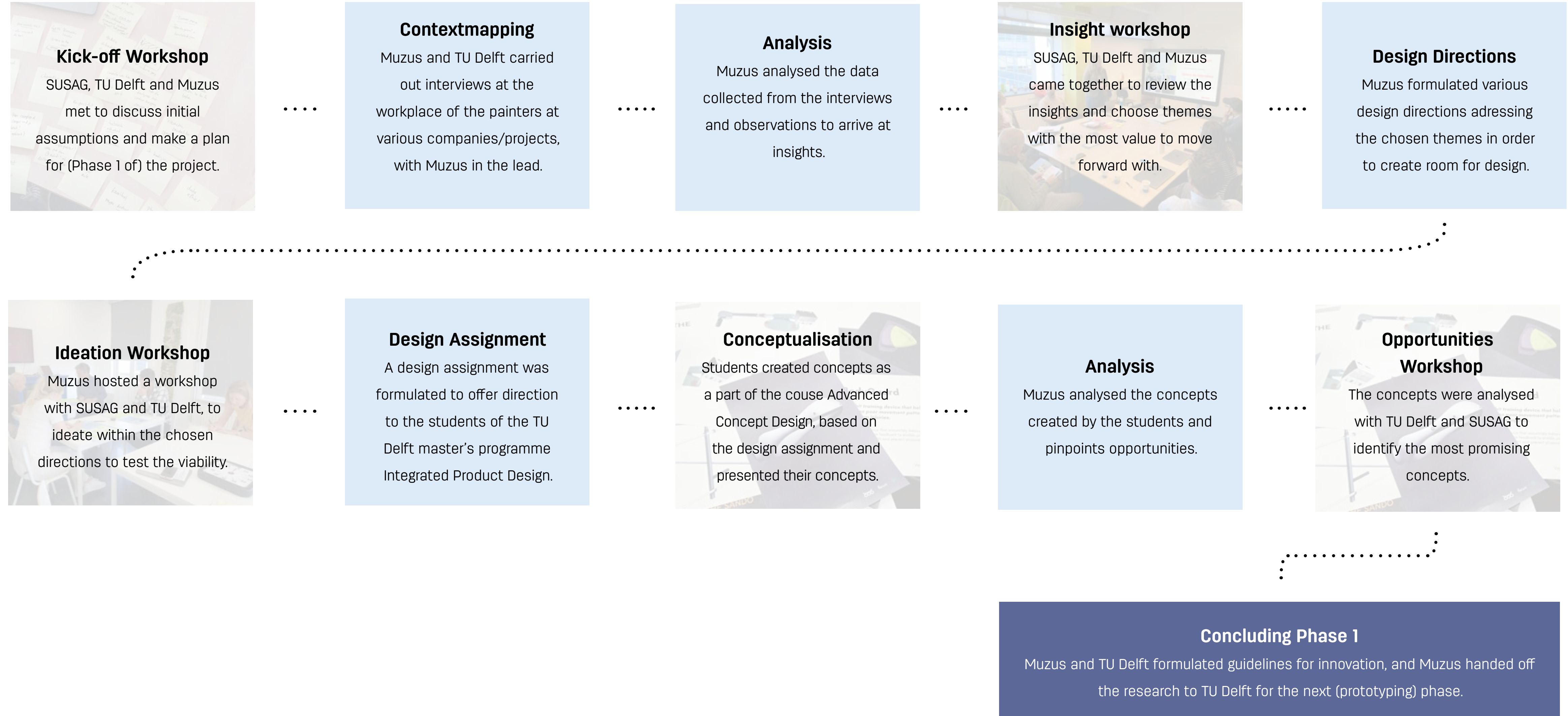

TU Delft
TU Delft researchers bring their insight into the theory, of smart agents, technological developments and trends. Students of the Master's Programme Integrated Product Design (TU Delft) design concepts based on the design assignment.

Process Overview

Kick-off Workshop

SUSAG, TU Delft and Muzus met to discuss initial assumptions and make a plan for (Phase 1 of) the project.

Contextmapping

Muzus and TU Delft carried out interviews at the workplace of the painters at various companies/projects, with Muzus in the lead.

Analysis

Muzus analysed the data collected from the interviews and observations to arrive at insights.

Insight workshop

SUSAG, TU Delft and Muzus came together to review the insights and choose themes with the most value to move forward with.

Design Directions

Muzus formulated various design directions adressing the chosen themes in order to create room for design.

Ideation Workshop

Muzus hosted a workshop with SUSAG and TU Delft, to ideate within the chosen directions to test the viability.

Design Assignment

A design assignment was formulated to offer direction to the students of the TU Delft master's programme Integrated Product Design.

Conceptualisation

Students created concepts as a part of the couse Advanced Concept Design, based on the design assignment and presented their concepts.

Analysis

Muzus analysed the concepts created by the students and pinpoints opportunities.

Opportunities Workshop

The concepts were analysed with TU Delft and SUSAG to identify the most promising concepts.

Concluding Phase 1

Muzus and TU Delft formulated guidelines for innovation, and Muzus handed off the research to TU Delft for the next (prototyping) phase.

General Introduction

Challenges in the industry

The painting industry embodies traditional craftsmanship, with an traditional work culture that may be resistant to change. Painters endure physical strain due to the manual labor involved, making it challenging to sustain a career until retirement without experiencing pain or health issues.

A need for change

The current state of the industry does not provide the healthiest conditions for the painters to work in. Traditions have been cemented in the work and practices, where it is difficult for the painters to realize there may be other ways to do the work. SUSAG acknowledges the need for change and innovation. But how? How do we integrate innovation into the daily systems and methods?

SUSAG wants to start an innovative movement in the painting industry. With the help of smart technology, we can make the painting profession future-proof: challenging, sustainable, healthy and indispensable.

Design goal

Develop smart agents for the future, based on the needs of painters and the possibilities technology offers. In this way, we let the painting industry discover what their future can look like, open the conversation, to move towards together.

Definition of Smart Agent

Smart agents are **autonomous entities** that interact with users or other systems, **making decisions, performing tasks, and adapting** based on data, learning, and predefined rules.

Creating Super Powers

As a result of the contextmapping research and the analysis of trends and developments in the painting profession, 3 design opportunities *(1. Ensuring Health, 2. Enhancing Craftsmanship and 3. Embracing Uncertainty)* were identified. These opportunities serve the various needs of the painters in supporting sustainable deployment. After the research done by Muzus and TU Delft, students of the master's programme Integrated Product Design at the TU Delft, took over to design concepts that focused on these opportunities. Once these concepts were delivered, the various concepts were compared and contrasted to create a better understanding of the potential in the future landscape of the painting profession.

FUTURE VISION

Future Vision

In order to understand the context of the future we are designing for, the design team has formulated a future vision. This was done in a brainstorm within the project team, with the trends and developments of the world and specifically the painting profession in mind, which are further elaborated on the next pages.

We, the project team, envision a future where painters are sustainably employed in an inclusive working environment. The profession is accessible for everyone (also women) with the drive, passion and skills for painting. Every painter can keep painting with pleasure. From the start of their career to their retirement.

Inclusive Work Culture

We dream of a future where the profession is inclusive, where anyone (no matter the gender, age or ethnicity) feels welcomed in the profession, and can find joy and thrive within their work.

Attractive to the New Generation

We dream that the profession stays attractive for new generations, adapting into the new needs and conditions of the future. In a world where the general mindset is changing, we dream that the painting profession can fit into the new norms without losing its core.

Enhancing craftmanship

We dream of a future in which painters are proud of what they do. Where craftsmanship is never lost, and is enriched with smart technology. So that the work becomes easier, lighter, and healthier, without losing the challenge.

Ensuring health

We dream of a future in which painters have no other choice than respect their body and mind. Their tasks do not harm their posture and they are protected. Smart technology can make them feel encouraged to make the right choices in the interest of their own health, without losing quality and efficiency.

Embracing Uncertainty

We dream of a future where uncertainty brings opportunity. Painters are flexible in organizing their own activities and tasks and adapt to changing circumstances such as weather conditions, working conditions, collaboration partners, new working methods and innovative tools. They are open to learn from each other, develop in areas of interest.

Trends and Developments

House painters may have the opportunity to work with cutting-edge tools and technologies, enhancing both efficiency and job satisfaction. From machine learning to Internet of Things, the world is changing and new technologies are becoming more prominent. Embracing and mastering these technologies can take the painter to the future, while resistance may leave them behind. After a thorough desk/literature research, the following trends and developments have been identified.

Need for lifelong learning

The pace of technological advancement and the evolving nature of industries will require workers to be adaptable and embrace lifelong learning. Even though the speed of innovation has been slow thus far in the painting profession, the future will require the profession to keep up with the technological advancements. The ability to adapt quickly to meet changing job requirements will become essential. Collaboration will remain a key player in learning, improving productivity, fostering innovation, and contributing to the delivery of high-quality work. Cultivating a sense of teamwork and shared responsibility among painters, will ultimately benefit both the professionals and their clients.

Need for emotional intelligence

With automation taking over routine and repetitive tasks, the demand for skills that are uniquely human will increase. Soft skills such as emotional intelligence, critical thinking, problem-solving, creativity, adaptability, and effective communication will be highly valued. These skills enable individuals to navigate complex situations, collaborate with others, and provide a human touch in interactions, not only with the customers but also within the team.

New working conditions

Many countries and companies have been partaking in studies to move to shorter work-weeks and allowing the employees to be in charge of their own planning. Employers and employees have realized the benefits of flexibility and work-life balance. Many opt to work in the hours where they are most productive, as opposed to standard set times. Within the preliminary results, the flexibility has been found to have a positive effect on the job satisfaction of many.

Inclusive Work Culture

The painting industry has historically been perceived as traditionally male-oriented due to the heavy work, but societal shifts and recognition of the importance of diversity have sparked positive changes. There is a growing emphasis on equal opportunities, breaking gender stereotypes, and promoting inclusivity in all professions, including painting. As awareness and acceptance continue to increase, more women and individuals from diverse backgrounds are likely to pursue careers in painting. This shift will bring fresh perspectives, varied talents, and increased creativity to the profession, fostering a more inclusive and representative industry.

Foster motivation and passion

Alignment with passions and personal development are becoming more important. People value pursuing what matters most to them more than what society is requiring them to do. As this has also become easier to do with time, individuals will seek out jobs and professions bringing them joy, and therefore will carry out tasks with more motivation. On the other hand, those who are doing a job because there is no other option are becoming less and less productive. Ownership and dedication are key players in motivation and development, both personal and professional.

The power of craftmanship

House painting is a form of craftsmanship. Painters take pride in delivering high-quality finishes and paying meticulous attention to detail. Automated painting systems are being developed to efficiently apply paint to large areas, reducing the need for manual labor. However, intricate and delicate work will still require human painters, especially since this is the area most painters take pride in.

The importance of health

Various professions are constantly prioritizing employee well-being by offering benefits and healthier options. Be it the physical health or mental health, in many areas of the job market the interest has risen in encouraging employees work more sustainably. Safety regulations and standards will continue to evolve, focusing on protecting employees' health and minimizing risks. This is also visible in the painting profession, with advancements in personal protective equipment (PPE), such as more comfortable and efficient respirators or protective suits, becoming commonplace to ensure the safety of painters.

Manage new expectations

The nature of work has been evolving, with the "side-hustle culture", remote work and flexible employment arrangements gaining popularity. These trends offer individuals greater freedom to choose the type of work they engage in, and heavy labor may not align with the preferences of all individuals. Many individuals prefer occupations that provide intellectual stimulation, autonomy, and opportunities for personal growth. However, there has been an increasing emphasis on intellectual and creative work. House painting offers a canvas for creative expression, and in the future, painters might have more opportunities to showcase their artistic abilities. Accentuating this may be integral in drawing in the new generation.

The importance of sustainability

The growing concern for the environment and sustainability will influence the job market. Companies are increasingly focusing on incorporating sustainable practices into their operations, and there will be a demand for professionals who can contribute to sustainability efforts, such as renewable energy, green technology, waste reduction, and eco-friendly initiatives. For newly produced equipment and materials, environmentally conscious products will be preferred. This can also be seen in the painting profession, for example in the incorporation water based paints.

Extreme weather conditions

With climate change, there may be an increase in extreme weather events such as hurricanes, storms, heatwaves, or heavy rainfall. These events can disrupt painting schedules and pose safety risks for painters. They may lead to project delays, damage to partially painted surfaces, or the need for additional preparation and protective measures. Contingency plans are necessary with the increasingly unexpected events of the future.

SMART AGENTS

Designing Smart Agents

In today's world technology has become a daily tool. From the smart phones we use to the robots who make our mundane tasks easier. With agents growing more autonomous, trust between user and smart agent is more important than ever.

When working with smart agents, several considerations come into play. These are also used within the design requirements of the final design assignment. From ethics to expectations of smart agents, the design must be made with the target group in mind. What makes a smart agent acceptable, and what needs to be considered in design?

Abilities and appearance

Smart agents are autonomous entities that interact with users or other systems, making decisions, performing tasks, and adapting based on data, learning, and predefined rules. Smart agents can have different forms, ranging from robots — complex machines that perform practical tasks independent of humans — to humanoid or animal-like characters that can communicate with people. Smart agents can also refer to smart wearable technology that can be worn, like exoskeletons, or to agent technology integrated in clothing or accessories like protective gear. Smart agents can also have a digital manifestation. Consider chatbots that you can converse with in apps on smart devices. In the context of this work, it would be interesting to know what our target audience desires smart agents to do and what they should look like in order to become accepted in their profession.

Interaction and Presence in Context

Beside the ability and appearance of smart agents, people's interaction with them matters as well. Our research at TU Delft focuses on how interactions with smart agents, are part of the larger web of relations that professionals sustain with their equipment and with each other. In other words, what makes a work practice meaningful considering the people, tools, and values at play? A relevant question here is how smart agents are present at work. Do they remain unnoticed, in the background of people's awareness or should they be explicitly present? Drawing attention to themselves as an innovative new piece of technology? When new technology is introduced to a work context that doesn't fit in, it will not become accepted. By investigating the painters work context in detail, we will know more about their practices, attitudes towards technology, and the reasons for embracing smart agents in their work. But also why painters might reject them.

Design Ethics

Introducing new technologies in work contexts raises ethical issues. Smart agents have the ability to adapt and make independent decisions Therefore is becomes important to allow users to 'opt-in' or 'opt-out' by providing them with the choice to either participate or not participate in specific interactions or services offered by smart agents. Furthermore, the behavior and decision-making processes of smart agents should be understandable and transparent to users, allowing them to gain insight into how agents operate. Because smart agents make of use data, data ethics is also in important consideration. Agents gather data through sensors, process it computationally for making decisions, and use it to activate functions, hereby producing more data. This data is stored locally in the device and on remote servers. Data should therefore be handed carefully, ensuring people's privacy and security.

State of the Art

The use of lighter and more convenient equipment has become prevalent, without any significant alterations throughout the years. The biggest innovation thus far has been tools powered by battery instead of long and heavy cables.

These innovations include support materials like exoskeletons (designed for a broader spectrum of professions, not specifically made for painters) and house painting robots. The technology ranges from assisting to taking over.

Attempts to integrate technology in the painting profession have not yet become the norm. Robots and technology are not widely adopted due to complex environments and the need for human expertise in precision and client interactions.

Exo-skeletons

Among others, Festool has created an exoskeleton, ExoActive, for heavy/overhead work. (E.g. Image above)

The exoskeleton promises to "make light work of strenuous overhead tasks. By reducing the stress on the user's body, they can work more effectively, focus more on the quality of their work, and ultimately get more enjoyment out of what they are doing."

Robots

There are currently robots on the market aiming to take over strenuous work with varying degrees of autonomy.

Robots with controls require the painters must be very good with technology, have the technical skills to be able to control the robot, but also have the painting skills to ensure the quality of the work is good. (E.g. Walt the Bot, image above)

(Fully) automated robots are set up once and does the rest of the work, painter is excluded then no longer needed, just serves as someone who can set it up (E.g. Myro, image on the right)

CONTEXTMAPPING

Context-mapping

The Method

We used the methodology contextmapping to explore the needs and experiences of painters. Contextmapping is a form of design research developed at the TU Delft. It makes use of Make&Say techniques with which the participants reflect upon their own context en thresholds and motivations come to surface. De method makes use of assignments instead of questions and explores in an open and rich manner which needs exist with a specific target group.

For this project, main purpose was to understand the painters' needs from their own perspectives and to identify the different areas in which "super powers" can serve a purpose when considering smart agents.
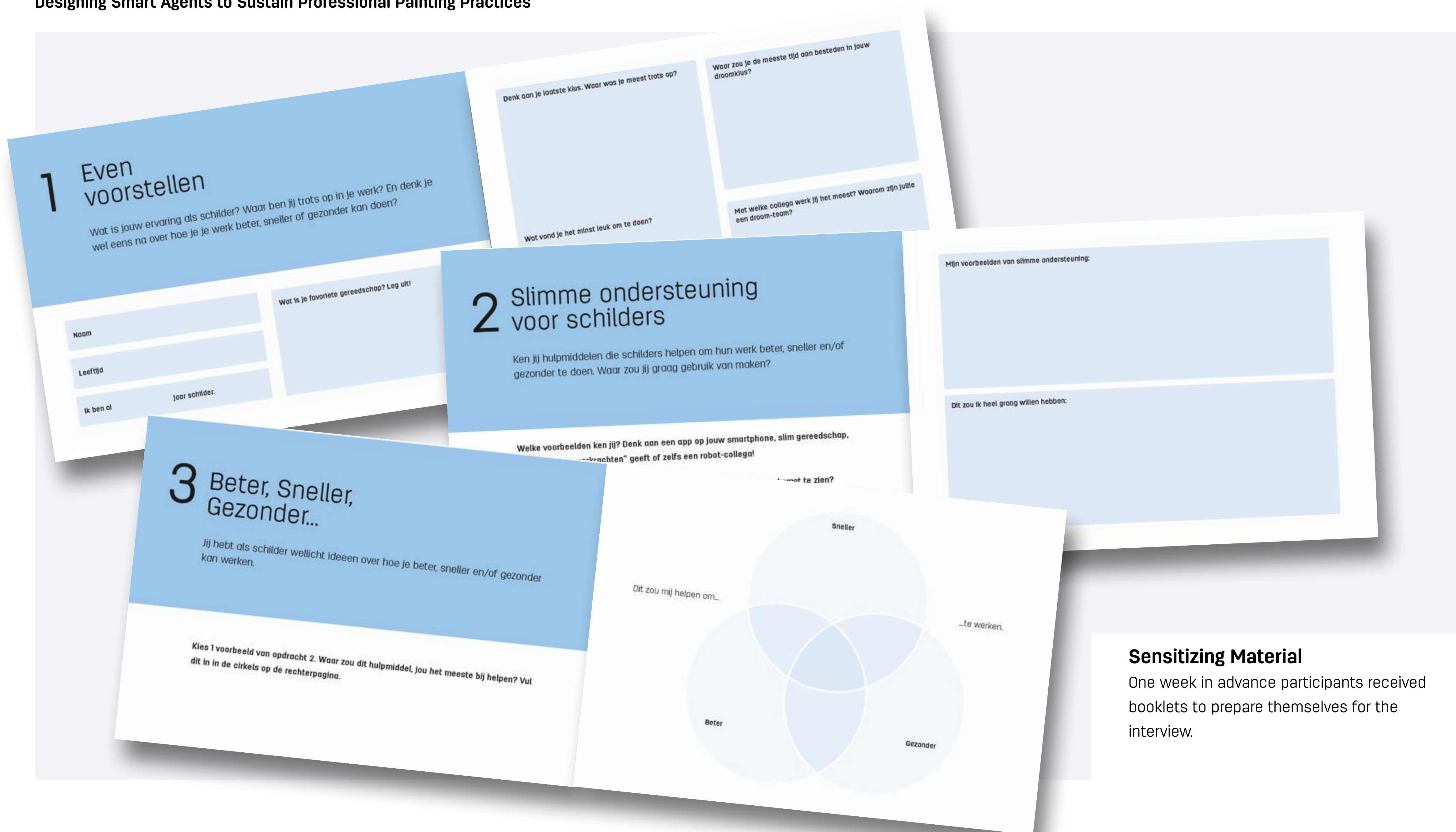
Research Setup

1. Sensitizing painters
2. Interviews by Muzus and TU Delft
3. Analysis
4. Insights
5. Opportunities

Participants

> 21 male painters, in groups of 2 or 3. We could not interview women.
> Interviews combined with observing while working.
> Age varies from 21 to 65 years old.
> Experience varies from 2-35 years.
> Working in different regions in the Netherlands. (As seen on the map above)

Lenferink

Heko

Lenferink

Jeurissen

Derks

Elk

Willems

1 Even voorstellen

Wat is jouw ervaring als schilder? Waar ben jij trots op in je werk? En denk je wel eens na over hoe je je werk beter, sneller of gezonder kan doen?

Wat is je favoriete gereedschap? Leg uit!

Naam

Leeftijd

Ik ben al ___ jaar schilder.

Denk aan je laatste klus. Waar was je meest trots op?

Waar zou je de meeste tijd aan besteden in jouw droomklus?

Wat vond je het minst leuk om te doen?

Met welke collega werk jij het meest? Waarom zijn jullie een droom-team?

2 Slimme ondersteuning voor schilders

Ken jij hulpmiddelen die schilders helpen om hun werk beter, sneller en/of gezonder te doen. Waar zou jij graag gebruik van maken?

Welke voorbeelden ken jij? Denk aan een app op jouw smartphone, slim gereedschap, ... arbeidskrachten" geeft of zelfs een robot-collega!

Mijn voorbeelden van slimme ondersteuning:

Dit zou ik heel graag willen hebben:

3 Beter, Sneller, Gezonder...

Jij hebt als schilder wellicht ideeen over hoe je beter, sneller en/of gezonder kan werken.

Kies 1 voorbeeld van opdracht 2. Waar zou dit hulpmiddel, jou het meeste bij helpen? Vul dit in in de cirkels op de rechterpagina.

... met te zien?

Dit zou mij helpen om...

Sneller

...te werken.

Beter

Gezonder

Sensitizing Material
One week in advance participants received booklets to prepare themselves for the interview.

Context-mapping

Interviews were carried out on site during projects with the painters. The interviews were done with groups of painters in a form of a semi-structured interview. The interviews took around 1-1.5 hours each, with an observation/shadowing part in addition to the 'sit-down' interview.

The interview took the sensitizing booklets as a base, with the questions being split in the same sections as the booklets. First the painters explained their answers and then further questions were asked. The interviews concluded with a small co-creation session where the painters were asked about ideas for smart agents. This wasn't done with the same extensivity in each interview, as the participants differed in approach and attitude.

0. Observation

Upon arriving, to break the ice and also get an understanding of the context and tools used in the daily lives of the painters, the painters showed us around the site, and explained the project. In some cases they also demonstrated various actions, and showed techniques as well.

1. Getting to Know

This section was used to understand the background, preferences, the importance assigned to different aspects of their work, their daily routine. In further questioning, physical complaints and steps taken to address them were also inquired.

2. Smart Agents

This section explored the painters' thoughts on "smart agents," discussing specific examples, understanding the potential benefits of technology in their daily life and work, inquire about desired tools and existing use of smart tools.

3. Better, Faster, Healthier

The last section helped identify the painters' priorities: exploring the understanding and prioritization of "faster, better, and healthier" and the painter's willingness to delegate tasks to smart agents. Different design possibilities for support with the examples of wearables, apps, tools, and robot colleagues were also discussed in the form of a compact co-creation session. Additionally, the purpose here was to identify the factors that would build trust in the smart support system, and defining characteristic for the smart agents.

Discoving Insights

All interviews were analysed and quotes were extracted from each transcript in order to obtain the initial data, in the form of post-its. This data was divided into types of insights: observations, quotes and ideas (as shown by the colour of the post-its in the image on the left).

These were then clustered by likeness to eachother and labelled accordingly. Each post-it may have multiple labels, referring to various themes and where relevant the form/interaction of a smart agent. As there are multiple labels on the same piece of data, the same post-it may show up again in another cluster, maybe in a cut-down version of the quote. These clusters were brought together to create various design directions to move forward in. Some themes were more general, not fitting into any specific directions, serving as overarching conclusions and tension fields in the field. These findings are divided into 3 sections: Main Themes, Approach Towards Smart Agents and Tension Fields, further elaborated on the next pages.

Findings

Main Themes

1

> Balancing Priorities in Painting
> Not Prioritizing Health and Safety
> Enhancing Communication
> Embracing Change
> Navigating Uncertainty

3

Read more →

Approach Towards Smart Agents

2

> The Future According to the Painters
> Prior Experience with Smart Agents
> Expected Form
> Expected Interaction
> Ideas about Smart Agents

Read more →

Tension Fields

3

> Generational Differences
> Work Culture

Read more →

Reading Guide

This report includes insights from both desk research and contextmapping research involving interviews with painters. Quotes from painters that validate these insights are attached to each insight.

Additionally, every insight is labeled with one of three corresponding labels, representing the three design assignments derived from the overall project. These design directions offer insights into their origins.

Explanation of insight

All insights are explained further, with examples where necessary.

Relevant quote

If the insight is obtained from a painter, the insight is supported with a quote.

Changes in Planning

Planning is often difficult, many clients do not take external influences into account and that causes a lot of strain on the mental health of the painters. Often the employers are also under pressure and the team can feel that there is no room to discuss the possibility to change plans as they will be held responsible for delays.

PAINTER, 55 (26 YEARS EXPERIENCE)

"The work pressure is high. They expect for you to have it ready in the given time, they don't look at the weather conditions."

HEALTH   UNCERTAINTY

Owner of the quote

For each quote the characteristics of the person who said the quote are specified by their function, age and years of experience, to better understand the context of where of whom the quote is coming from

Label

All insights are marked with corresponding labels, there may be more than one label per insight. There are 3 labels in total which indicate the relevant design opportunity. These are:

HEALTH   *Ensuring Health*

CRAFTSMANSHIP   *Enhancing Craftsmanship*

UNCERTAINTY   *Embracing Uncertainty*

Main Themes

This section explains the main findings from the context mapping interviews according to various themes that were spotted. These reflect the current situation of the painting profession and express the opinions of the painters.

Balancing Priorities in Painting

Not Prioritizing Health and Safety

Enhancing Communication

Embracing Change

Navigating Uncertainty

Balancing Priorities in Painting

Painters take pride in delivering excellent results and value recognition from colleagues, managers, and clients. Assessment considers both quality and speed, but in today's world, high speed is necessary to meet the needs of a large number of clients. A clash of priorities can arise between painters and employers. Painters prioritize quality above all else, followed by speed. However, employers may prioritize faster production. Both aspects are monitored by the employer, while the health of the painter is primarily the responsibility of the painter themselves as well as comfort. Smart agents can help in balancing these conflicting priorities and help them coexist without hindering the craftsmanship, even enhancing it.

The Big Picture

In the painting profession, there is a common understanding among painters that the actual painting process is only a small portion, approximately 30%, of the overall job. The remaining 70% is dedicated to thorough preparation. While outsiders may primarily associate the painting profession with the act of painting itself, painters view the project as a holistic endeavor that encompasses both preparation and painting. For painters, the preparation phase is crucial as it sets the foundation for a successful and high-quality outcome.

Pride in the Results

High-quality work also gives the painters a lot of pride, especially when seeing appreciation from others (collegues, manager or client) and helps with job satisfaction.

Requirements

Assessment is often based on quality and speed, different requirements are set for each project. The speed affects the planning and quality affects the result. The client pays for a certain quality and expects it to be done in a certain amount of time and this is the main consideration in the planning.

Unrealistic Demands

The expectations from the employer and the client can sometimes be unrealistic, and endanger the mental health of the painter, which is often not seen. High workloads and dismissal of unexpected delays by the client/employer can have a negative impact on the job satisfaction of the painter in the long term.

Clashing Priorities

The priorities for the 2 points are different for the painters and the employers. Where the painters prefer delivering higher quality, for the employers faster production can be more important.

PAINTER, 59 (22 YEARS EXPERIENCE)

"They do want you to be done by a certain time, how it's done doesn't matter. **When the workload is that high, it is no longer fun.**"

`CRAFTSMANSHIP` `UNCERTAINTY`

PAINTER, 44 (28 YEARS EXPERIENCE)

"**Health would be at the top and then quality and then speed.** Speed is ultimately not the most important part for me, **it is for my boss.**"

`CRAFTSMANSHIP` `HEALTH`

PAINTER, 22 (2 YEARS EXPERIENCE)

"**I am most proud of the end result.** Sometimes things don't go right and you feel horrible during the process, but then **you look at the result together with colleagues and then you feel proud.**"

`CRAFTSMANSHIP`

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"We are judged on **quality and speed.**"

`CRAFTSMANSHIP`

"You shouldn't become a painter if you're not willing to have some **knee problems**. I know very few painters who work until retirement. **They all stop earlier.**"

- FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

Not Prioritizing Health and Safety

Many painters commonly experience health issues, which have now become an inherent aspect of the job description. Painters go into the profession being aware that at some point they will experience physical strain. Many painters are even forced into early retirement due to pain or at times even disability. There is a shift in mindset in the profession towards prioritizing health over solely focusing on results. Although some older painters view this shift as a weakness, many focus on teaching the new generation properly, learning from their own mistakes. By leveraging technology, smart agents can contribute to a safer and healthier environment for painters while also supporting their professional development and encouraging lifelong learning on how to do things even better and healthier. Smart agents can aid in supporting painters and lighten the load, to allow them to work with pleasure and do their craft for as long as they like.

Who is in Charge of Your Health?

Safety is often a question among painters, where they find it difficult to assess a situation and whether it is safe or not. There may also be tension between painter and employer, where the painter cannot decide for himself if he feels safe. This is also the case in providing personal protection equipment is obligatory, but in practice it is not always provided.

Proper Education

Older painters are aware of the health problems and try to train the younger ones better. There is a definite focus on educating the new generation properly.

Physical Strain

Due to the heavy physical load, there are many health problems, to which many painters have become accustomed. Health problems seem to now belong in the job description. Most painters suffer from pain and many do not make it to retirement as they have to stop earlier.

Overcoming Prejudice

There is a definite prejudice towards the shifting priorities of the newer generation. The older generation was taught that "you can do anything" or "it won't kill you" where carrying out tasks became more about the result rather than the road leading up to it. In the past, showing strength took precedence over being healthy. If you wanted to be succesful, you had to show how much you can do. This mindset is shifting, and that is also visible in the profession. Older painters have different views on this shift, with some being more judgemental referring to it as a "weakness", while others more understanding of the new norms, learning that change may benefit them as well.

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"We have the knee pads, which I do not find useful to work with. **I do want the young people to do that. They have to be on their knees for years to come**"

HEALTH

PAINTER, 55 (26 YEARS EXPERIENCE)

"The question is **not which one you get (personal protective equipment), but whether you get it at all. It shouldn't be a point of discussion,** it's about health"

HEALTH

PAINTER, 53 (32 YEARS EXPERIENCE)

"And especially the younger generation, they are also much more open to supportive tools, and it is necessary. **In the beginning I thought "hey, don't exaggerate", but they have a point, it really is important for your health.**"

HEALTH

FOREMAN/INSTRUCTOR PAINTER, 44 (28 YEARS EXPERIENCE)

"**You often start too late.** The moment your knee starts to bother you, you think oh now I have to try. **I think if you started using aids at a younger age, you will get used to it more easily.**"

HEALTH

Enhancing Communication

Effective communication is not always easy, but is necessary in the painting profession. There is a need for emotional intelligence and good social skills. Most painters are very social and do not shy away from a conversation. This is necessary to keep the project flowing. However, conflicts can arise, either within the team, with the employer or even with clients. When priorities are not aligned or the situation is not properly communicated, the joy that the painter gets from their work and craft can be hindered. The use of smart agents can foster better collaboration and knowledge-sharing within the team, bridging the gap between age and experience levels. By facilitating effective communication, smart agents can contribute to improved teamwork, client satisfaction, and overall project success.

Many Stakeholders

There are many stakeholders (client, painter, manager, etc.) and they do not always have the same priorities, communication between the stakeholders isn't always easy and/or straightforward. When communication between the painter and the employer isn't good, conflicts can arise, which at times can result in unjust labels, such as "uncooperative".

With Residents and Neighbors

Communication with residents and neighbors is important. Painters have to be able to quickly assess: "this one is not good with jokes, we are going to be serious". Occasionally they have to help residents at home. That prevents problems. There is a definite "human" aspect to the profession.

Bonding with colleagues

The painters find that bonding in and outside work helps in understanding the thought process of the other, making the project much easier.

Trust and Support

Trust and communication in the team is vital for individual job satisfaction. Communication between colleagues also aids in creating a higher quality result.

Hierarchy and Experience

Communication within the team is important for job satisfaction. There is a hierarchy in the profession and respect for age and experience is expected but not always there.

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"Sometimes you also have **colleagues that you don't click with, then the work is much more difficult.**"

`CRAFTSMANSHIP`   `UNCERTAINTY`

PAINTER, 55 (26 YEARS EXPERIENCE)

"**You have to be open and learn from each other. I'm not going to explain to someone with a lot of experience how to do something** with an open mouth, young people often do that**.**"

`CRAFTSMANSHIP`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"**You get people from all walks of life. So communication is the most important.**"

`CRAFTSMANSHIP`   `UNCERTAINTY`

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"**I think the most important point is that we are all on the same page, and that there is trust that we support each other.**"
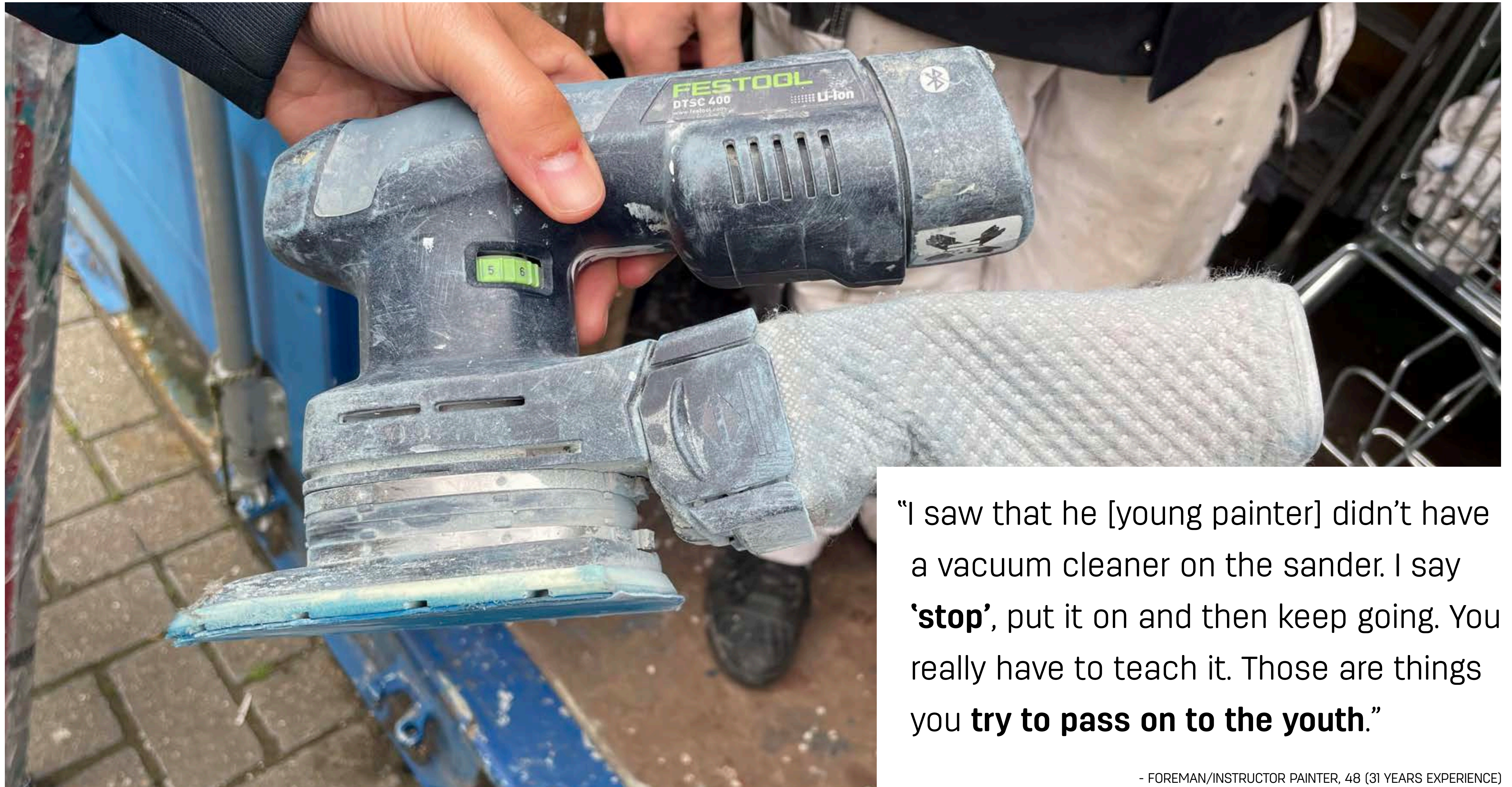
`CRAFTSMANSHIP`

PAINTER, 55 (26 YEARS EXPERIENCE)

"We don't know our safety rights. It's raining/snowing/wind/ice, can I go on it? **The manager says just do it. If you refuse, you will immediately get a stamp, "he will not cooperate".** We used to get into a lot of fights about this with the managers."

`HEALTH`   `UNCERTAINTY`

"I saw that he [young painter] didn't have a vacuum cleaner on the sander. I say **'stop'**, put it on and then keep going. You really have to teach it. Those are things you **try to pass on to the youth**."

- FOREMAN/INSTRUCTOR PAINTER, 48 (31 YEARS EXPERIENCE)

Embracing Change

To encourage painters to accept smart agents, a behavior change is needed. Currently, painters often choose unhealthy practices due to familiarity. Where the new generation is more adaptable, older painters may resist new methods. Individual techniques and lack of standardization contribute to craftsmanship, but hinder change. Painters' perceived stubbornness and resistance to change pose challenges. At the moment craftsmanship and use of technology are perceived as polar opposites. An important challenge to overcome is showing that technology can enhance craftsmanship instead of making it cease to exist.

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"We are a bit stubborn - after 30 years of experience you shouldn't tell me how to do things."

CRAFTSMANSHIP   HEALTH

Embracing the New

Most painters often still choose the "unhealthy option" because they are used to it. For example, sanding without a face mask and gloves or washing your hands with turpentine. Experience and age seems to be a determining factor in adapting to new things, where the older painters are more set in their ways. Mainly instructor painters, who are responsible for the education of new painters are understanding of the new norms and adapt more easily to new practices.

Personal Practices

Often a painter will have developed his own way of doing things, this is less true for new painters. Also in teaching the job, many painters will educate the younger painters with their own methods and what they found throughout the years to work best, and the methods are passed on. There isn't a standard in which things are done, and this helps with the craftsmanship and personal satisfaction

that comes with the job. Giving the space for creating your own method and the flexibility within the team for everyone to do so can help with the individual satisfaction.

Resisting Innovation

The physical strain is high and there are many health problems, but "you cannot be a painter without health problems". In many situations, the painters don't see a problem that needs a solution, they see it as a job description, and therefore find innovation unnecessary.

A Stubborn Group

The painters are often very "stubborn" as they describe themselves. With the traditional work they have been doing for years, many painters can often be closed to new methods, and can even actively push them away.

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"When you say 'do it that way', they say 'no we have been doing it that way for 40 years'. **There is nothing to discuss with or anything, that's it, that's how they do it and that's how they will keep doing it.**"

CRAFTSMANSHIP   UNCERTAINTY

PAINTER, 40 (15 YEARS EXPERIENCE)

"Every painter has his own way of doing things. If I do it according to 'abc' and he does it via 'ceb', that should be possible."

CRAFTSMANSHIP   UNCERTAINTY

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"**I think everything has already been invented for support, improvement may be possible, yes, but is that necessary?**"

CRAFTSMANSHIP   HEALTH

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"We now have sand soap. No irritation, we are aware, and we pay attention to it. There are still people here who wash their hands with turpentine. **There are people who still do what they aren't supposed to, but fine.**"

HEALTH   UNCERTAINTY

Navigating Uncertainty

The painting profession's Uncertainty and challenges require effective communication, teamwork, and innovative problem-solving. In many cases where uncertainty is high, the painters can have an immense amount of stress placed on them. With many thing being out of their control, decisions also become difficult to make. Technology can play a role in streamlining the process, and making sure that the decision is not made at the expense of the painter's health. Embracing smart agents can enhance efficiency and help painters navigate uncertainties more effectively, ensuring successful outcomes in their craft.

Changes in Planning

Planning is often difficult, many clients do not take external influences into account and that causes a lot of strain on the mental health of the painters. Often the employers are also under pressure and the team can feel that there is no room to discuss the possibility to change plans as they will be held responsible for delays.

Extreme Weather

The weather (especially in the Netherlands) is quite unpredictable, and plans have to be made around weather conditions. The main consensus is to keep 'inside-work' or any work that doesn't hinge on the weather conditions for the end of the job and utilize the better weather days first. This doesn't always work out in practice. Painters, mainly the foremen, have to rely on apps and forecasts to make decisions, and cannot always fully trust them. They are responsible for the results no matter what decision is made, and many feel extra stress as there is only so much you can plan for.

Unexpected Obstacles

There are also things like wood-rot or asbestos that can stop all work or have to be worked around, this can also create extra work or major delays. In the daily work, there is a lot of on-the-spot solutions to make sure that the work goes on as planned. In these cases it becomes very important that the team has good communication and trust, as it is often teamwork and mutual understanding that helps everything move smoother and faster to get back on track. In many cases experience and technique is also necessary, to weigh out the options and understand the possibilities, to eventually come up with creative solutions. Many painters enjoy this part of the process, seeing it as a puzzle to solve, while others have a set method and do not like having to stray from it.

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"**The work pressure is high. They expect for you to have it ready in the given time, they don't look at the weather conditions.**"

`HEALTH` `UNCERTAINTY`

INSTRUCTOR PAINTER, 48 (31 YEARS EXPERIENCE)

"**There is always something to do, if the weather is suddenly good in the afternoon you want to be on location, it saves travel time.**"

`CRAFTSMANSHIP` `UNCERTAINTY`

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"We don't work with asbestos, you will come across that sometimes. **We discuss it, we do less things, we don't do any sanding.**"

`UNCERTAINTY` `HEALTH`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"**We are so used to it, before you start, you look at the weather forecast.** The app indicates sun, but I see clouds and when it indicates rain, the sun is shining. Then I think, who even came up with this.**"**

`CRAFTSMANSHIP` `UNCERTAINTY`
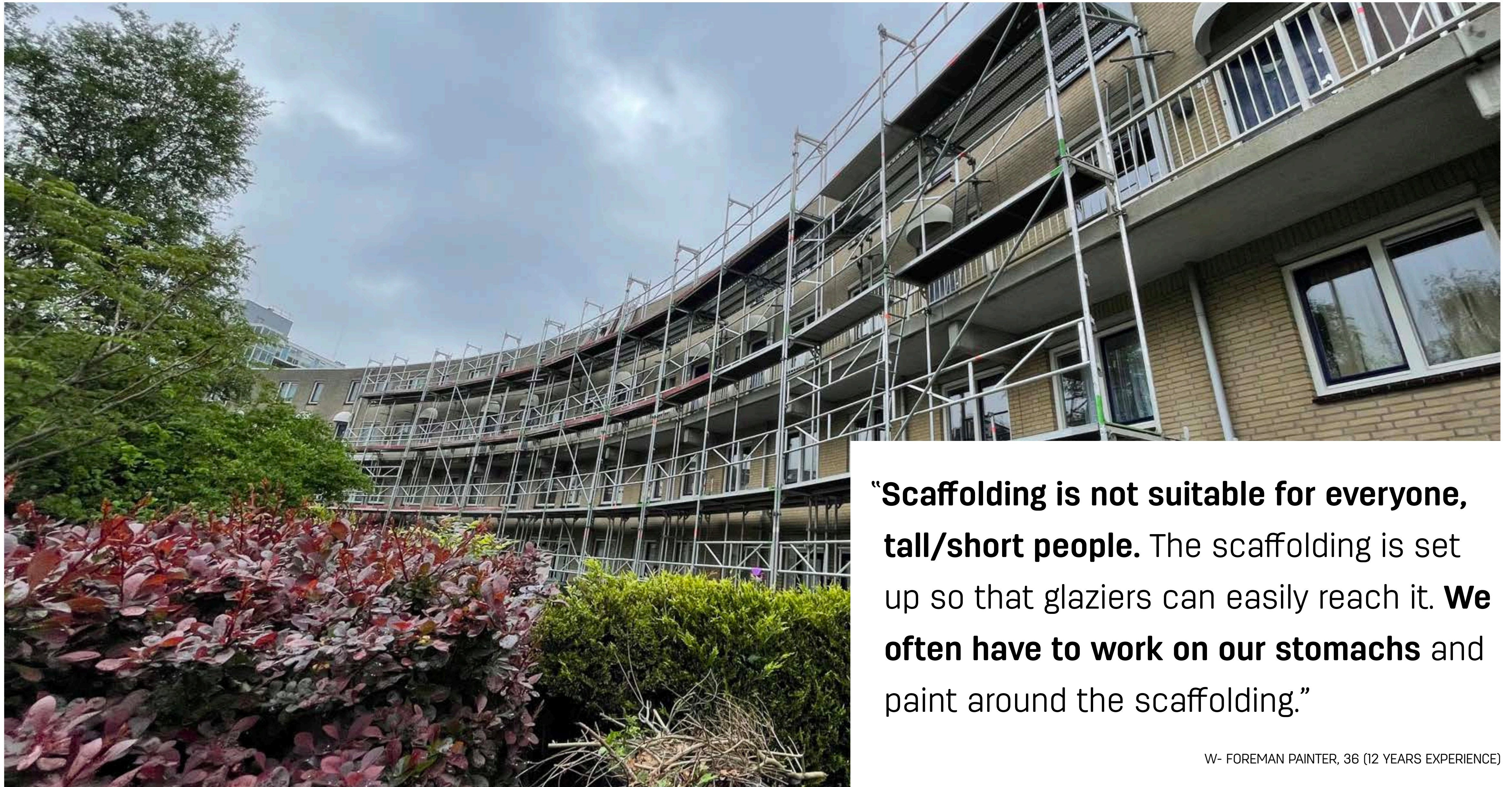
"**Scaffolding is not suitable for everyone, tall/short people.** The scaffolding is set up so that glaziers can easily reach it. **We often have to work on our stomachs** and paint around the scaffolding."

W- FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

Approach Towards Smart Agents

This section explains the perspective of the painters regarding the future and use of smart agents. These help in identifying the various expectations and requirements to keep in mind when designing smart agents for painters.
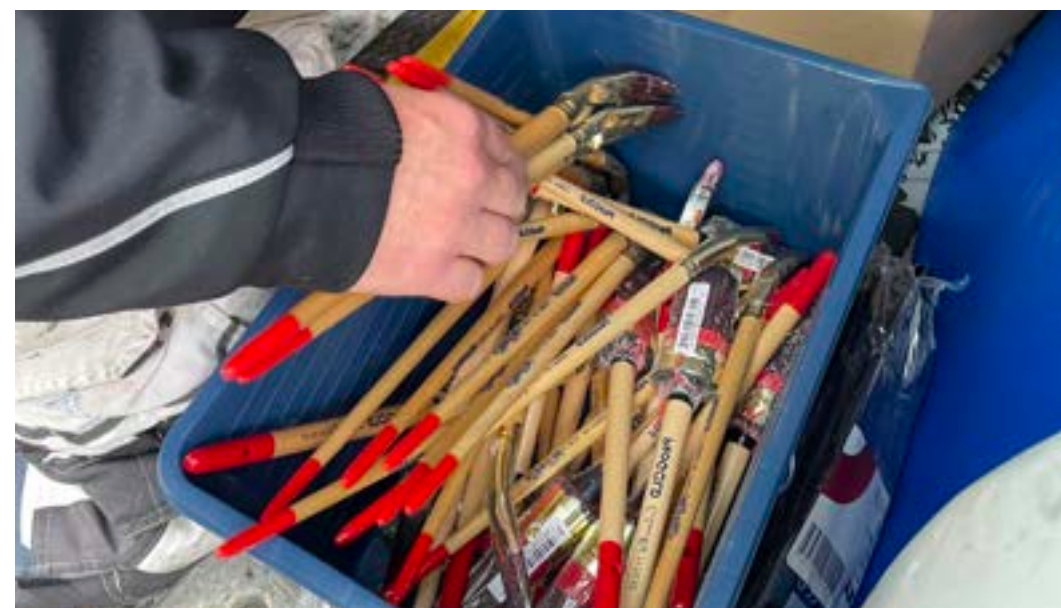

The Future According to the Painters

Prior Experience with Smart Agents

Expected Form

Expected Interaction

Ideas about Smart Agents

The Future According to the Painters

The painters express skepticism about the ability of robots to perform the intricate task of painting. The younger painters are generally more open to the possibility of enriching their craft with technology, whereas older painters often fear it, and perceive their craft as a skill that is best performed by human hands and worry that automation could render their profession obsolete. They believe that painting requires a level of creativity and finesse that machines may not possess.

The painters also emphasize that painting is not solely about technical skills but also requires independent thinking and decision-making. They express concerns that relying on robots could diminish these qualities. There are also visible fears about the possibility of losing their jobs to robots.

The painters recognize the value of innovation in their profession, but these innovations remain quite simple. Many examples given include efficiency, but some also refer to enhancing the craft, e.g. better brushes. Some also mention the role of innovation in bringing the profession to the future, with inclusivity becoming an important part of the work.

The painters express broader concerns about the increasing influence of AI and automation in society. They worry that excessive reliance on robots and AI could lead to the loss of certain skills. They find the rapid advancements in artificial intelligence unsettling, possibly due to a lack of familiarity or understanding of the technology. It is possible to infer from their opinions about the future that the innovation lies in enhancing and not on replication.

INSTRUCTOR PAINTER, 65 (45 YEARS EXPERIENCE)

"Exoskeletons and robots will always be in the way."

HEALTH   CRAFTSMANSHIP

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"Do we want robots to do everything in 50-60 years? If there is a staff shortage, you have to look at where that went wrong, **how can we encourage this? Don't use robots. People are getting dumber.** Everything is being taken over, we constantly need programs to calculate things. **If we have robots for everything we are going in the wrong direction"**

CRAFTSMANSHIP   UNCERTAINTY

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"A robot wouldn't be able to paint I think, maybe in the future"

CRAFTSMANSHIP   UNCERTAINTY

INSTRUCTOR PAINTER, 30 (7 YEARS EXPERIENCE)

"Women have less strength. Exoskeletons can help with that."

HEALTH   CRAFTSMANSHIP

PAINTER, 28 (10 MONTHS EXPERIENCE)

"Yes, then we will soon have no work. **I think painting is hard work and is done with your hands, sometimes it has to be really sleek, that would not be possible if robots did it,** we are not robots.**"**

CRAFTSMANSHIP   UNCERTAINTY

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"When you see what all that artificial intelligence can do, it doesn't make you happy! It's just scary. Maybe it's because we don't know"
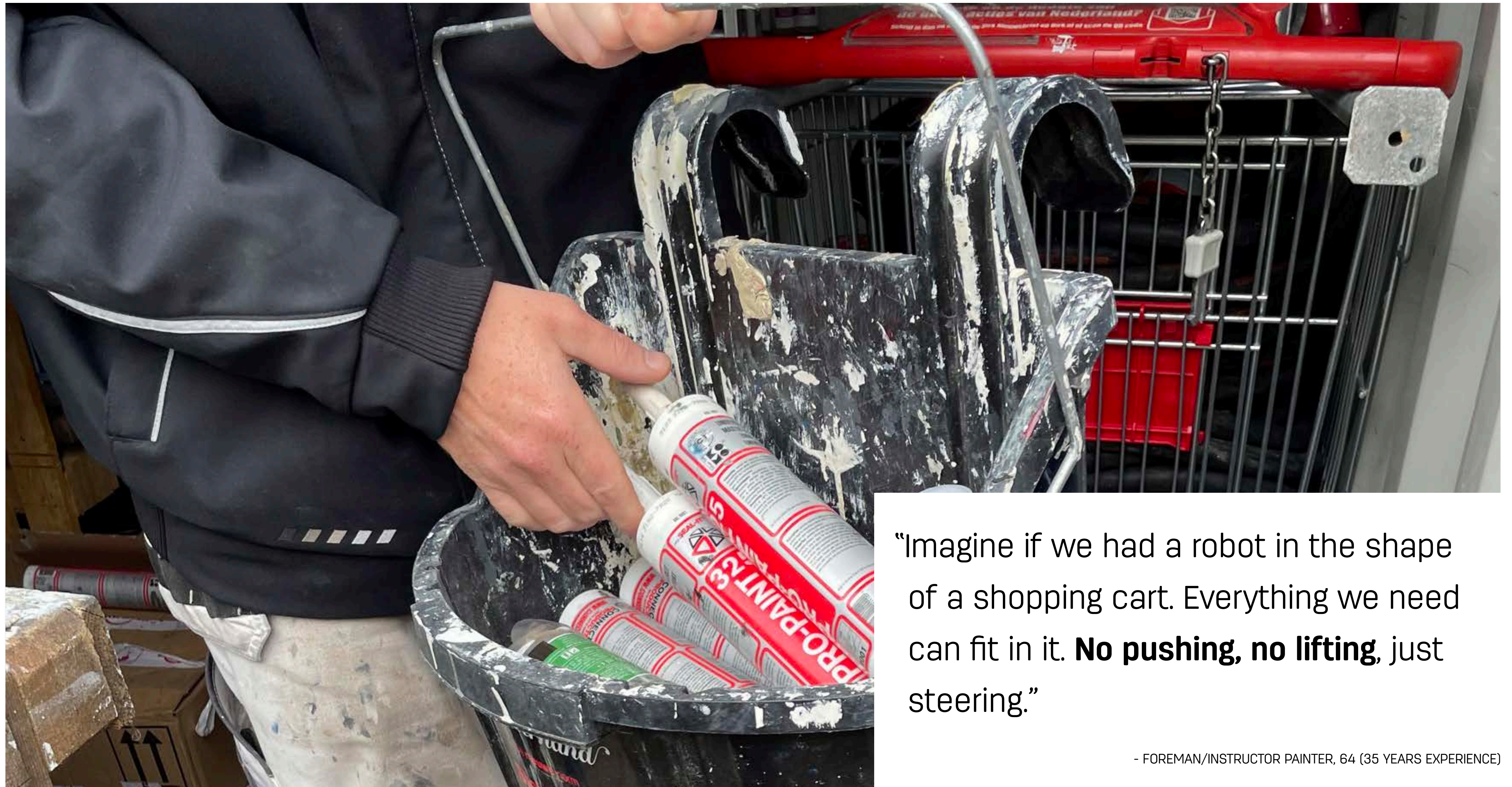
CRAFTSMANSHIP   UNCERTAINTY

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"Innovation is at the level of the tools you use. A new brush that can go into corners, new kind of hairs, new kind of hair..."

CRAFTSMANSHIP

"Imagine if we had a robot in the shape of a shopping cart. Everything we need can fit in it. **No pushing, no lifting**, just steering."

- FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

Prior Experience with Smart Agents

Painters do not have much experience with smart support. Their grasp of "innovation" is often limited and is based on the improvement of products they are already familiar with. As the painters themselves often do not get invited to fairs where new products are introduced, they are often not aware of innovation. If the employers don't deem it worthy of being brought to the practice of the company, it never reaches the painters themselves. Some painters do research in their private time, and seek out new technology, with a few having heard of exoskeletons. The opinions here were varied, with some finding it to be 'amazing' and others who have tried it on themselves finding it to 'get in the way'. There is something to say here about the timeframe that the products were tried in, as there has been progress in the designs as well, so the opinion may change if tried now.

None of the painters had heard of automated robots used to paint walls. There was a general skepticism when introduced to

such examples, with most not trusting that the robot with work, and others pointing out that it would be a very expensive investment, which their company wouldn't be okay with. The painters voice a a general negative opinion towards exoskeletons and robots, suggesting that they see these technologies as obstacles rather than aids to their work. They perceive such technologies as intrusive or incompatible with their craft, which may be a point to consider when introducing new agents into the context. The general idea is that smart agents can help with efficiency but there is skepticism about the quality of the result.

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"Perhaps there will be support for that. I had seen such a robot arm. [if it can ease the work] **yes, if it's comfortable. You should not have 2-3 kg on your back all day. Then it goes off quickly.** But you get used to everything, they say."

`HEALTH`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"We did have a robot here. With the long planks, putting the paint on it, smoothing it out. **But that's back in the workshop, that wouldn't work in practice.** Things aren't delivered ready-made, **you have to consider what exactly what needs to be done.**"

`HEALTH` `CRAFTSMANSHIP`

PAINTER, 55 (26 YEARS EXPERIENCE)

"I do look things up in my private life. You have painting fairs, I like that too, I haven't done it yet. **Certain types of people get those tickets. People on top, not the ones doing the real work**"

`HEALTH` `CRAFTSMANSHIP`

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"**I think it has to be more something with physical like those arms or that can help with your knees now and then.**"

`HEALTH`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"A colleague of mine had worn that exoskeleton and **he says 'you have no idea what it's like'. It makes everything lighter**"

`HEALTH`

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"**Straight forward work is okay (exoskeleton) but otherwise it's very difficult**"

`CRAFTSMANSHIP`

PAINTER, 55 (26 YEARS EXPERIENCE)

"**I put on someone's robot arm, and I can't even get that high with my shoulder, then it stops. It remains an obstacle.**"

`HEALTH`

Expected Form

When painters think of "smart agents," they often initially envision humanoid robots, leading to concerns about job replacement and limited flexibility. However, alternative forms such as tools, wearables, and apps were introduced, sparking different opinions. The key expectation is ease of use and seamless integration. The agent should not be an added burden and should fit well into the painting context.

Personalization and adaptability are crucial, as each painter's needs and physical strain differ. Wearables and tools were preferred, as they are familiar and easier to adopt compared to entirely new concepts. The general ideas that were generated during the interviews mainly stemmed from already existing tools, like brushes that can keep a straight line. Apps were dismissed due to limited practicality on the workfloor, while robots were met with skepticism regarding their potential to take over.

Precision and personalization were emphasized for wearables, particularly exoskeletons. Though prior experiences or hearsay influenced judgments, painters were generally open to the idea, albeit some considered it unnecessary. The majority of painters do have trouble imagining delegating tasks, as they see everything as a part of the job, with some going as far as saying that if they didn't do a certain part that is tedious or maybe physically straining, they wouldn't be doing their job right, and it isn't anything they cannot handle. There is a general idea that use of smart agents can make you look weak. Therefore, enhanced, supporting items were preferred over delegating.

PAINTER, 44 (28 YEARS EXPERIENCE)

"That would of course be an option if you could have all that wirelessly via an app. That in itself could have a function. **You also have to measure now and then you have to write things down or pass them on, you could just save everything right away on that phone.**"

CRAFTSMANSHIP   UNCERTAINTY

PAINTER, 55 (26 YEARS EXPERIENCE)

"For support, it is very useful for your knee or your shoulder. **But then it really has to be for that part [of the body], not for everything at the same time. Must be very specific and precise to fit well.**"

HEALTH

PAINTER, 22 (2 YEARS EXPERIENCE)

"It has to be comfortable. It has to guide a bit, but above all it has to give strength. Should make your work easier"

HEALTH

PAINTER, 40 (15 YEARS EXPERIENCE)

"The disadvantage of something like this is that it cannot be seen in how opaque it is. **The eye sees more.** If you do it yourself, you can see whether it will sink or not, that thing can be adjusted, **but every surface is different, every wall is different.**"

CRAFTSMANSHIP   UNCERTAINTY

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"If we had a robot in the form of a shopping cart... That we could put everything we would need in there and **instead of pushing it we could steer and not have to lift**"

HEALTH

PAINTER, 22 (2 YEARS EXPERIENCE)

"Must be easy to carry, I don't want to drag it around"

HEALTH

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"I'd rather have something that fits around you. Depending on the weather, whether it should be on all day"

HEALTH   UNCERTAINTY

"**The only major innovation** I see for the next few years is that turpentine-based paint will disappear and become **water-based**, and maybe **new brushes**"

- FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

Expected Interaction

Painters want to maintain their expertise and control over the painting process, preferring technology to complement their work rather than replace it. They are cautious about fully trusting robots as the main executor of their tasks.

Painters appreciate smart agents for efficiency and speed in tasks like rolling ceilings or sanding. Having robots for specific projects is appealing but may reduce task variety, which some painters enjoy.

Painters prioritize technology that aligns with their working style and requirements. They have concerns about the limitations and trust in smart agents, particularly in dealing with delicate surfaces, navigating obstacles, and performing flexible tasks. Many painters are hesitant to fully trust non-human touch.

Overall, painters approach smart agents with caution, valuing support and efficiency. They seek adaptable, flexible, and complementary technology. Smart agents are viewed as a way to lighten the workload and

enhance painting, but painters emphasize the importance of retaining their vital role in the process due to their expertise and livelihood being central to their profession.

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"In that respect, they are a stubborn bunch, painters. If it's not sitting right in the beginning, you can forget about it right away."

HEALTH

PAINTER, 55 (26 YEARS EXPERIENCE)

"**I would prefer to have the robot do the sanding, but that is very difficult.** It must be really flexible. **Just try to find a robot that can climb a flight of stairs or avoid an obstacle.**"

HEALTH   **UNCERTAINTY**

FOREMAN/INSTRUCTOR PAINTER, 53 (32 YEARS EXPERIENCE)

"**It used to be that the younger guys went ahead first** and they had to sand everything. That's how it was. **If you could get a robot for that... You set it up and it gets going then you just have to look. Then we just finish up.** I don't know how long that would take, but I think it will be difficult.**"**

HEALTH   **UNCERTAINTY**

PAINTER, 22 (2 YEARS EXPERIENCE)

"Sometimes when the scaffolding is built, the scaffolding builders walk away and leave us with a lot to clean, **such a robot could be handy when cleaning up.**"

CRAFTSMANSHIP

FOREMAN/INSTRUCTOR PAINTER, 57 (36 YEARS EXPERIENCE)

"Look, we have to get our work done. And we enjoy our work. So it should help us that we can do lighter work, but that in the end we do the work and not the robot because yes, it is our bread and butter. Everything that falls under support is fine, but not that it will take over the entire shop."

CRAFTSMANSHIP

PAINTER, 22 (2 YEARS EXPERIENCE)

"[Robot that can do everything] should dust, sand, but if there is glass I would not trust so quickly, if your glass is damaged you are really in a problem, then new glass has to be put in. Then the boss is not happy either"

UNCERTAINTY   **CRAFTSMANSHIP**

Ideas about Smart Agents

During the interviews, a condensed co-creation session was done, by giving the painters 4 forms the smart agents could possibly take (app, wearable, tool, robot colleague) and letting them generate ideas. Wearables and tools were received the warmest, however when asked to create smart agents in the form of a wearable or a tool, the discussion did not go further than slight (not necessarily technological) changes to their existing tools. The most innovative thinking came from the younger painters, with some suggesting enhanced tools and wearables, which they themselves also categorized as "superpowers". The ideas were quite personal, and didn't always receive the same reaction from the other painter that was present during the interviews, there were some disagreements at times about whether something would work in practice or even if it was necessary in the first place. These are some examples that the painters came up with.

INSTRUCTOR PAINTER, 30 (7 YEARS EXPERIENCE)

"Some sort of death switch/control system – being able to override the system"

`HEALTH` `UNCERTAINTY`

PAINTER, 28 (10 MONTHSEXPERIENCE)

"Brushes that are in compartments, and then paint comes out, in America you see that, yes, you would spend quite a lot of time making work easier and faster."

`CRAFTSMANSHIP`

INSTRUCTOR PAINTER, 30 (7 YEARS EXPERIENCE)

"Robotic octopus arms to help with carrying things"

`HEALTH` `CRAFTSMANSHIP`

FOREMAN PAINTER, 36 (12 YEARS EXPERIENCE)

"Control weather to prevent rain"

`UNCERTAINTY`

INSTRUCTOR PAINTER, 30 (7 YEARS EXPERIENCE)

"A brush that keeps straight motions"

`CRAFTSMANSHIP`

PAINTER, 22 (6 YEARS EXPERIENCE)

"Sensors in a glove to show whether everything is smooth without removing it. Gloves must be resistant, go over different surfaces, and should not be thrown away in 2 weeks. Shouldn't be too heavy either. You have to do everything with it."

`HEALTH`

`CRAFTSMANSHIP` `UNCERTAINTY`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"Teleport to other parts of the site"

`HEALTH` `UNCERTAINTY`

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"Gloves with sensors, green light when held properly?"

`HEALTH` `CRAFTSMANSHIP`

PAINTER, 45 (22 YEARS EXPERIENCE)

"Clear instructions on how to maintain and clean it."

`CRAFTSMANSHIP` `UNCERTAINTY`

INSTRUCTOR PAINTER, 30 (7 YEARS EXPERIENCE)

"Iron-man boots to keep you in the air, travel easier up and down, to places on site and provide stability."

`HEALTH` `UNCERTAINTY`

Tension Fields

This section goes into the challenges in bringing the profession to the future and 2 tension fields in regards to the position of the profession in the world right now and where trends are expected to go.

Generational Differences

Work Culture

Generational Differences

Interest in Innovation

The younger generation of painters show more interest in technological advancements in comparison to older painters. They are more open to embracing new tools and smart agents in their painting practices. This curiosity stems from their familiarity with modern technology and a willingness to explore innovative solutions to improve their efficiency and workflow. Their receptiveness to technological developments indicates a shift towards a more tech-savvy and forward-thinking approach in the field of painting. However, it is still important to realize that the profession is still quite traditional, whether it will remain so in the future or not is unclear, but either way, the younger painters often also describe themselves as "traditional", and that is a part of the profession that will most likely remain. Currently, within training there is more focus on technique and less on innovation. There is room for innovation to be introduced to the training, as that is a key in drawing in the new generation.

Greater Focus on Well-Being

The current educational landscape places a greater emphasis on health and well-being, and this focus has influenced the younger generation of painters. As they learn from their teachers, who often follow traditional techniques, a potential challenge arises. The traditional methods may not always align with the modern understanding of health and ergonomics. While these methods may be rooted in the history of the craft, there is a need to strike a balance between traditional practices and health-conscious approaches. Young painters must navigate the dilemma of adhering to time-tested techniques while also making healthier choices that prioritize their well-being in the long run.

New Way of Dealing with Situations

The younger generation approaches situations in a manner that differs from the older painters. Some older painters perceive the new generation as "weaker," there is definitely a contrast in attitudes. This difference in perspective could be attributed to changes in societal norms and expectations. It is evident that the profession of painting has not fully adapted to the current standards of work. Heavy physical work and limited flexibility are prevalent concerns. Young painters, growing up in a time of increased job variety and opportunities, may not be as inclined to tolerate physically demanding tasks. This is also reflected currently in the number of student painters being trained, where many come from painter families, and it is not as common anymore for a young painter to join the profession without any prior connection. As a result, there is a call for the painting profession to evolve and address these issues to attract and retain the interest of the younger workforce.

PAINTER, 21 (2 YEARS EXPERIENCE)

"There are fewer and fewer people who want to become a painter. **I was in a class with 9 people, which is not enough.**"

CRAFTSMANSHIP
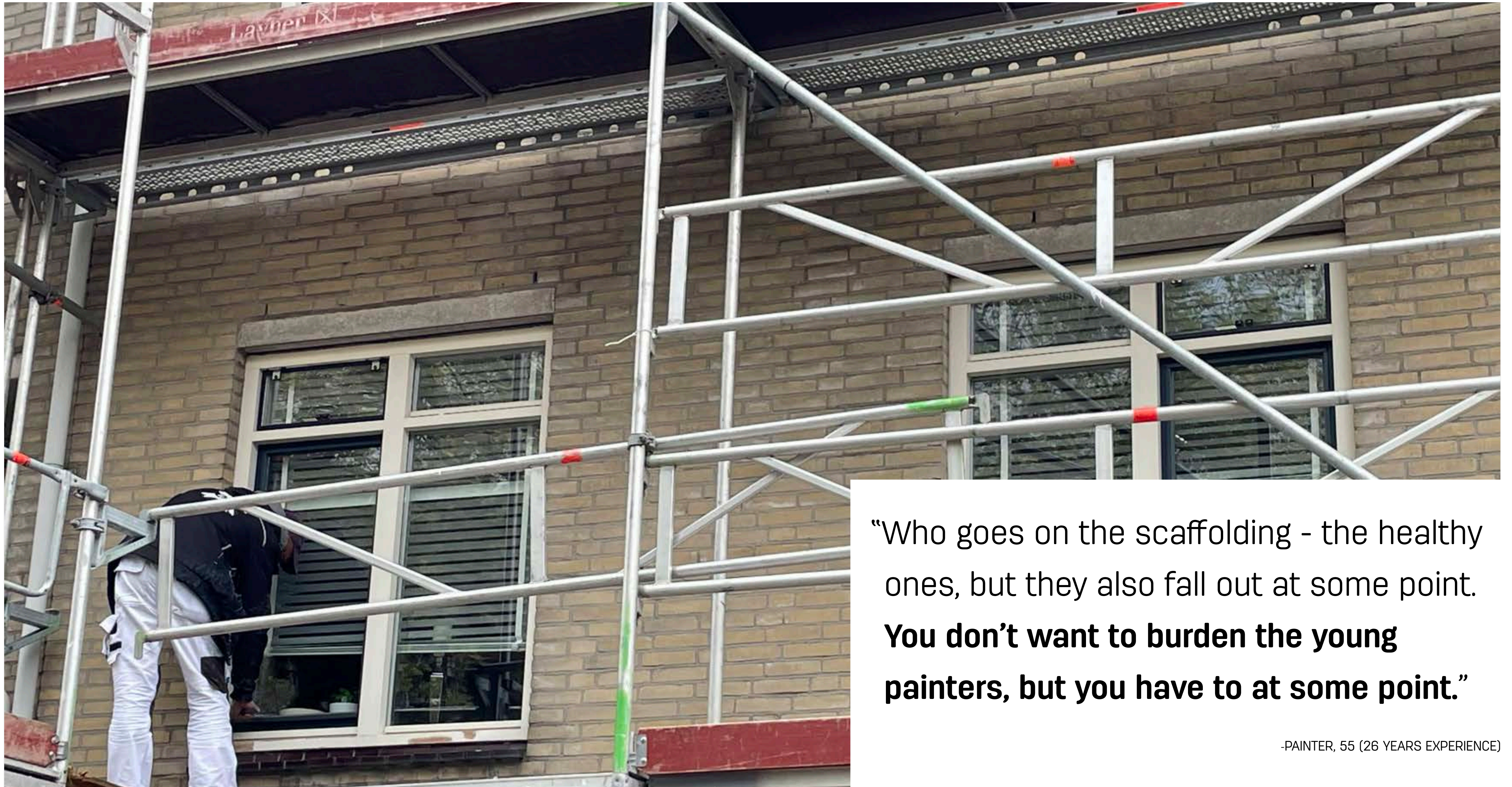
PAINTER, 22 (5 YEARS EXPERIENCE)

"You see gloves worn more often nowadays, with the older generation less. **They are not so used to it. That is really hammered into my training.** Gloves, ear protection…"

HEALTH

FOREMAN/INSTRUCTOR PAINTER, 64 (35 YEARS EXPERIENCE)

"**Physical condition of youth is deteriorating,** 2 of them are lifting a ladder **while it weighs nothing.**"

HEALTH

PAINTER, 55 (26 YEARS EXPERIENCE)

"**Generation makes a difference - when it is cold and windy they don't want to, they are suddenly 'sick'. Many young people do not have the same discipline**"

HEALTH

"Who goes on the scaffolding - the healthy ones, but they also fall out at some point. **You don't want to burden the young painters, but you have to at some point.**"

-PAINTER, 55 (26 YEARS EXPERIENCE)

Conclusion of the Contextmapping

The goal of our Contextmapping research was to determine the criteria that smart agents should meet to align with the needs of painters and ensure their sustainable deployability.

Quotes and observations from interviews with a diverse group of painters were extracted and categorized into different types of insights, which then concluded in 3 design assignments.

Painters are often hesitant about smart agents, as they want to preserve their expertise. Smart agents can provide support without making the profession obsolete, and there is a need for flexible and adaptable technologies to assist painters in their work.

Overall, the research highlights the challenges and opportunities presented by new technologies and innovation in the painting profession. It advocates for a dynamic and adaptable work culture to embrace innovation and advance the field.

Ensuring Health

The significance of the preparation phase is highlighted as it lays the foundation for a successful and high-quality end result. Prioritizing health and safety is crucial in the painting profession, as many painters face health issues due to the physical demands of their work. In the research we found that priorities between painters and employers are sometimes conflicting, the importance of health and safety in the painting profession, and the potential of smart agents to enhance efficiency in work, decreasing the physical demands. Painters place great value on delivering high-quality results and seek recognition from colleagues, clients, and customers. They emphasize the importance of striking a balance between speed and quality to meet the demands of a large number of clients while also prioritizing the well-being of painters.

Enhancing Craftsmanship

Painters place great value on delivering high-quality results and seek recognition from colleagues, clients, and customers. They emphasize the importance of striking a balance between speed and quality to meet the demands of a large number of clients while also prioritizing the well-being of painters. Effective communication, both within the team and with clients, is vital for project success. Smart agents can serve as valuable tools to support communication, collaboration, and knowledge sharing. Expectations of painters regarding smart agents include promoting efficiency and enhancing the work experience. Automation in the painting process, fearing that such technologies may render craftsmanship redundant. Painters desire technology that aligns with their work practices and needs, complementing their expertise rather than replacing it.

Embracing Uncertainty

The painting profession also faces uncertainties and challenges, making effective problem-solving and decision-making crucial. Smart agents can streamline processes and support painters in dealing with uncertainties. Smart technology's ability to collect, analyze, and respond to data in real time provides a foundation for flexibility in both personal and professional scenarios. Smart agents and automation can streamline processes, offer data-driven insights, and enable effective problem-solving in the face of uncertainties. These advancements empower individuals and professionals to adapt quickly and make informed decisions, enhancing their ability to navigate unexpected situations successfully. In bringing a certain amount of order to potential chaos, smart agents can lighten the mental load on the painters and help with their job satisfaction in the long-term.

CONCEPTUALIZATION

Design Assignment

The design assignment was formulated based on the findings of the contextmapping research. This assignment was provided to TU Delft master's students to further conceptualize.

"Design a smart support system for the sustainable deployment of painters, to give them "super powers". Use one of the points on the right as a means to shape the "super power"."

Design Requirements
The smart system must...

1. Inspire for innovation in the profession
2. Be feasible in the purpose it serves
3. Be viable in the context and interaction
4. Be desirable for the painters to use and meet their needs
5. Facilitate intuitive and trustworthy collaboration between user and agent

HEALTH

Ensuring Health
Feeling proud of creating, working efficiently, and ensuring quality demands a lot, both mentally and physically. The painting profession requires a conscious effort in keeping things "healthy", in all definitions of the word. Repetitive tasks, heavy equipment and potentially toxic materials play a large role in the physical demands of the profession, where as planning and communication can at times create a mental burden. The fine motor skills and the attention to detail required to deliver quality often take prescedence over health. But why can't these two aspects co-exist? **How can smart technology support painters' physical and cognitive health?**

CRAFTSMANSHIP

Enhancing Craftsmanship
The painting profession is known to abide by traditional techniques. The profession is passed down by one painter to another, often in practice, along with the craftsmanship and artistry. So far, innovation has been seen as a crux in keeping the tradition alive. The industry needs to move along with its time, embrace the technological possibilities without losing craftsmanship. There is a need for a step into facilitating lifetime learning, instead of clinging to outdated methods. New methods can also encourage craftsmanship, and even become a part of tradition for future generations. **How can technology enhance the craftsmanship and embed itself into the tradition and culture?**

UNCERTAINTY

Embracing Uncertainty
Both the working environment and the job itself always have unpredictable aspects. Think of changing weather conditions, unexpected wood-rot, or even colleagues on sick leave. These conditions, among others, can influence the work and planning of painters. Painters also have their own preferences in working hours, variation vs. specialization, personal interests, pride and ownership, all influencing job satisfaction. In this unpredictable context, individuality tends to be moved to the background however is vital in job satisfaction. **How can smart technology aid in creating flexibility in unexpected situations, both in the personal and professional aspects?**

Overview of Concepts

About the Students

The students in this project belong to the Integrated Product Design (IPD) master's programme at TU Delft, with an educational background in technical design and ergonomics.

About the Context

The conceptualisation was a part of the Advanced Concept Design course, therefore a focus on mechanical qualities and ergonomics is prominent in the designs. Students had access to this report and were able to observe painters themselves, establishing a contextual foundation for their design work.

During the course (20 weeks) the students also had access to painters to do usability tests with, however not every student did/could. Due to the time constraints and requirements of the course, most students' conceptualisation resulted in a high fidelity prototype, but the full functionality was not tested. Students offered recommendations on future research to make the concept a reality.

The students, guided by the contextmapping research, have devised conceptual solutions aligned with the design assignment outlined on the previous page. Three design directions were provided, prompting the exploration of each, though the intention was for the students to select, at a minimum, one as their primary focus. It is crucial to note that emphasizing one aspect does not imply neglect of the others; rather, it signifies a concentrated effort to address a specific area of concern. Many students have explicitly mentioned their consideration of other areas. The themes of Ensuring Health and Enhancing Craftsmanship were the most common, and Embracing Uncertainty is considered in only a few.

A total of 16 concepts were developed, each tailored to distinct focuses and purposes. An overview of all concepts can be seen on the right. A summary of the designs are presented on the following pages. Not all concepts include smart elements, this is due to the nature of the course and the focus on ergonomics. Therefore each concept is labeled with a new label to indicate whether it integrates smart elements such as sensors or AI. *2 of the products, Steigerhulp and Sliding Armrest have been left out of the analysis, due to their fully mechanical nature and in and of themselves do not solve an existing issue. As also mentioned by SUSAG themselves, feasibility in use is also questionable. Therefore, these are explained (marked by *) but not further used in the analysis.* While half of the concepts are devoid of smart features, their inherent potential is acknowledged. Recommendations regarding the inclusion of smart elements are made by either the students themselves or, in instances where the consideration is lacking, by the project team.

Also with each concept, the type of interaction was described, the concepts are either **assisting** or **enhancing.**

Assisting

An assisting product is defined as providing support/guidance while carrying out a task. This could also mean that a task is delegated or it is a tool that adds to a certain task. Tasks that could have the same effect for the user if delegated to another painter.

Enhancing

An enhancing product is defined as making existing senses or functions of the painter themselves more efficient or augmenting new senses. It means that the product becomes a part of the person's being. The effect is not replicable if delegated to another painter.

Assisting
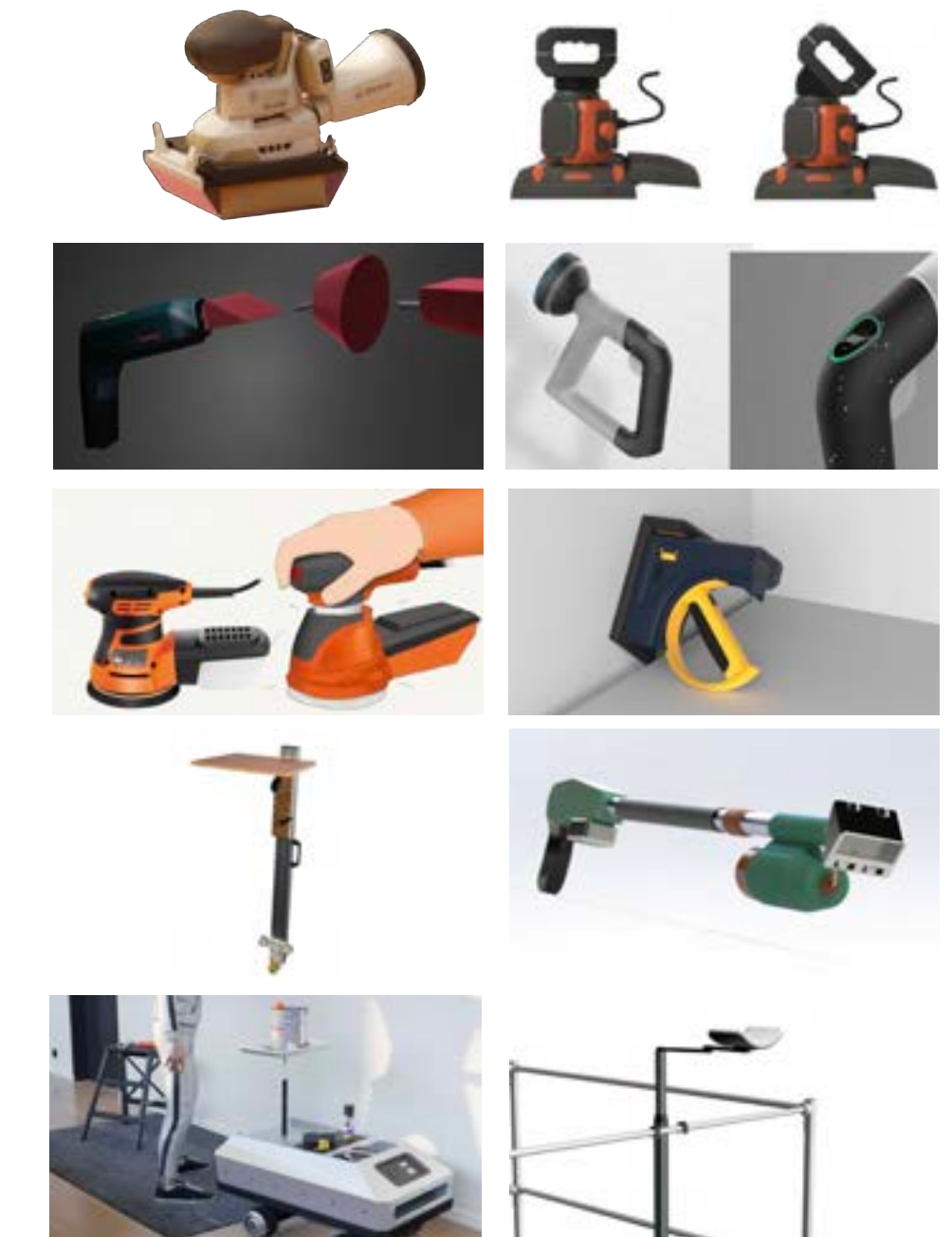
Enhancing

HEALTH **CRAFTSMANSHIP**

HEALTH

HEALTH **CRAFTSMANSHIP**

HEALTH

Sponge Sander

Vision: *"I want to design a silent, injury-preventative device that reduces the time of preparation of painting."*

Purpose: Ergonomic sander to minimize pain and labor for painters. With a flexible surface it allows for more surface area to be covered at once make the preperation time easier and faster. The efficiency resulting from the use of this concept allows focus on the actual painting task itself;

Agent: Has an *assisting* function. Fully mechanical; no smart elements. Intended to copy the human touch and detail with the flexibility but add speed to it to make it more efficient.

Innovation: The concept is designed for detail work, like windows, so is an addition to the workplace. It requires 3M flexible sandpape, which currently isn't industry standard. Business viability involves add-on modality for key manufacturers and integration into painting education.

Swivel Sander

Vision: *"Enrich the sanding experience for outside-house painters by reducing muscular strain."*

Purpose: Ergonomic sander aiming to minimize extreme postures by painters through a device that allows for flexible positioning while sanding. Enhances human capabilities by reducing the need to reach, kneel, or twist the wrist, delegating strenuous tasks, enhancing awareness and support through its design features.

Agent: Has an *assisting* function. Fully mechanical; no smart elements, the collaboration consists of automatic adjustments for better positioning and feedback from the painter. The control lies mainly with the painter.

Innovation: The ergonomics are interesting, yet require further testing. Embedding in practice can occur through its ergonomic benefits, potential for reducing health-related issues, and compatibility with current painting techniques. Will aim at replacing current sanders.

Sando

Vision: *"A design solution that aims to improve the efficiency and craftsmanship of the painting process while the painters can work in a natural and ergonomic posture while doing details in the sanding process."*

Purpose: A sander with a rotatable handle to ensure the painter doesn't do repetitive wrist movements, reducing strain and promoting natural postures. Concerns like minimizing fume and dust exposure are also considered.

Agent: Has an *assisting* function. Fully mechanical; no smart elements, but the student mentions potential with sensors in the future. Collaboration with the tool is described as enhancing the painter's capabilities without replacing traditional skills, ensuring a partnership that values human touch and craftsmanship.

Innovation: The sander aims to replace current sanders, but needs further research and collaboration with large manufacturers is necessary.

ACV Sanding Machine

Vision: *"Elevate existing traditional sanding tools to optimize ergonomics and reduce vibrations with 50% to create enjoyable experiences for painters"*

Purpose: The sander aims to reduce vibration on the painter's body, extending the time a painter can work safely and comfortably. It uses a Stewart platform mechanism to actively cancel out vibrations, thus supporting the painter by reducing the risk of permanent nerve damage and making the sanding process safer and more enjoyable.

Agent: Has an *assisting* function. Fully mechanical; no smart elements, designed to protect the painter, enhancing safety without sacrificing control or the quality of work.

Innovation: As the concept doesn't alter the traditional idea of a sander, the student expects the sander to be widely accepted. This concept is meant to replace the current sander. The feasibility requires further testing, especially to ensure that the Stewart platform functions as intended.

HEALTH CRAFTSMANSHIP SMART

HEALTH CRAFTSMANSHIP SMART

HEALTH

HEALTH

SandEase

Vision: *"Making the craft of painting more appealing by adding a helpful new product to the standard equipment of painters, that will help them do the sanding parts of their jobs easier"*

Purpose: Ergonomic sander with various heads for detail sanding, comfortably doing work that painters have to normally do themselves with less repetitive action. Meant for sanding areas like door or window frames, non flat surfaces where a regular sanding machine cannot be used.

Agent: Has an *assisting* function. Mechanical, tool with a force sensor, ergonomic grip, the painter still has all control, is informed about the force applied and receives further feeling of the work.

Innovation: It is an addition to the workplace, and isn't meant to replace existing sanders. It is a new product which means that it will have to be seperately bought and manufactured and the ergonomic feasibility requires further testing.

Ergosand

Vision: *"Ultimately, our goal is to enable painters to dedicate more of their attention and skills to the art of painting craftsmanship itself, thereby rekindling passion and interest in the painting field."*

Purpose: This sander aims to enhance the painting experience by streamlining the sanding process. It offers support through its ergonomic design, intelligent feedback systems, and customizable features, empowering users with more control and reducing physical strain.

Agent: Has an *assisting* function. There is a pressure sensor with real time surface status feedback. The interaction is collaborative, emphasizing ergonomics, intuitive control, and feedback mechanisms, enhancing control during use.

Innovation: Meant to replace existing sanders. There is not a new product so it is more likely for the painters to adopt it, however the form and shape is unfamiliar and therefore the acceptance has to be tested.

Steigerhulp*

Vision: *"Enhancing the daily lives of Dutch painters on scaffolding by supporting their tools and techniques, therefore increasing their productivity and reducing strain, so it will be adopted by painters."*

Purpose: This tool clicks onto scaffolding and carries products, aims to increase painters' productivity and reduce physical strain by supporting tools and techniques, thus augmenting human capabilities through ergonomic design and task delegation.

Agent: Has an *assisting* function. The design promotes a character of reliability and support, enhancing the user experience through form and function that complement painters' practices. A sort of assistant to the user and middleman between various users, making tasks easier and more efficient.

Innovation: In testing with the painters, the concept seems desirable, however the actual ease of use in practice needs to be further tested. It is an addition to the workplace.

Sliding Armrest*

Vision: *"Empowering painters to reach heights while preserving their well-being. A future where painters can effortlessly reduce the physical strain without sacrificing mobility, flexibility or control"*

Purpose: The armrest also clicks onto scaffolding so that the painter can lean onto it, it aims to reduce physical strain and enhance control during painting tasks without compromising mobility or flexibility. Reducing physical strain, especially on the shoulders.

Agent: Has an *assisting* function. Fully mechanical; no smart elements. The interaction with the tool is designed to be intuitive, integrating into the painter's workflow with minimal disruption, improving their sensorimotor skills without sacrificing the 'human touch' or pride in their work.

Innovation: The concept requires further testing and in and of itself does not fix the physical strain issue. On its own it is not a viable product to join the workplace.

HEALTH   CRAFTSMANSHIP

HEALTH   CRAFTSMANSHIP   UNCERTAINTY   SMART

HEALTH   CRAFTSMANSHIP

HEALTH   UNCERTAINTY   SMART

Tape it Easy

Vision: *"Develop concepts for embodied solutions that help painters engage in faster, better, and safer work practices and, in the long term, make the profession more appealing for the new generation of workers. "*

Purpose: It is a tool designed to improve efficiency and ergonomics in masking tasks. Unlike many other preparatory tasks, taping is quite straight forward and take little away from the painter's craftsmanship. The product uses liquid tape which an be directly sprayed onto any surface. It is adjustable and gives the painter a lot of freedom in their posture and the place they are taping.

Agent: Has an *assisting* function. Fully mechanical; no smart elements. Interaction with the tool is envisioned as ergonomic, intuitive, emphasizing ease of use and control.

Innovation: The product is already very desirable as is. It creates a flexible solution for a tedious and time consuming task. It is also a good step into enhancing job attractiveness.

Robotcart

Vision: *"Create a tool that has multiple functions, which has a supportiverole for the painters, improving their physical work conditions,that can make the craft more attractive for younger generations, and making the older generation last longer."*

Purpose: The robot is designed to carry the painter's tools and materials, thereby reducing physical strain and increasing efficiency. The robot can also maintain paint at optimal temperatures in unpredictable conditions and offers potential in many other functions.

Agent: Has an *assisting* function. The robot uses sensors to follow around the painter. The interaction with the agent is collaborative, emphasizing ergonomics, control, and ease of use, ensuring that it enhances the painter's ability to work efficiently and comfortably.

Innovation: The testing with painters shows room to integrate seamlessly in the workplace. The technology used may be costly in production.

Gecko

Vision: *"Improve the painter's health by addressing ergonomic challenges and reducing work-related injuries and chronic musculoskeletal disorders, without hindering the craftsmanship."*

Purpose: A sander with a wearable rotatable handle to ensure the painter doesn't do repetitive wrist movements, reducing strain and promoting natural postures. The main point is the wearable sander head, but the sander motor is also wearable, and distributes the weight making it lighter overall.

Agent: Has an *enhancing* function. Fully mechanical; no smart elements, but the student mentions potential with sensors in the future. Collaboration with the tool is described as enhancing the painter's capabilities without replacing traditional skills, ensuring a partnership that values human touch and craftsmanship.

Innovation: The sander aims to replace current sanders, but needs further research and collaboration with large manufacturers is necessary.

Brisa

Vision: *"Elevating the painting process to a satisfying experience, by making sanding more appealing and comfortable, while preserving painters' pride and craftsmanship."*

Purpose: Brisa is a headgear designed to protect by reducing exposure to harmful substances. Designed to be worn on the head, generating an air stream to protect against particulate matter.

Agent: Has an *enhancing* function. Serves as an enhancement of human capabilities, so that the uncomfortable protective gear is no longer required and allow them to be comfortable while they are preparing the space or doing their painting.

Innovation: Testing is required for adopting this into daily work practices without disruption, emphasizing viability and acceptance. It is a very different approach than the rest of the concepts, and has potential to cement itself as a new wearable in the workpace. It aims to replace other protective gear, but may be costly in comparison.
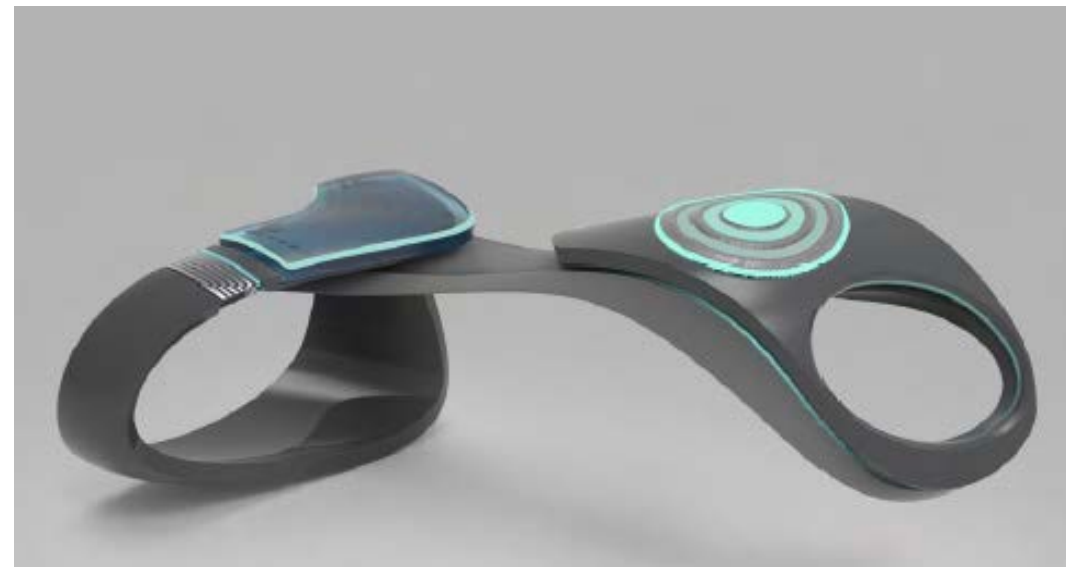
CRAFTSMANSHIP SMART

StrokeBeat

Vision: *"Providing "on-site instruction" that guides novices to learn and apply painting intuitively through gamification."*

Purpose: It fosters craftsmanship by maintaining artistic expression and eliminating tedious tasks, thus improving the painter's sense of craftsmanship through sensorimotor skills enhancement. It aims to help the new generation learn the craft in a new and gamified way.

Agent: Has an *enhancing* function. The device offers support through gamification, haptic feedback, and light notifications, enabling intuitive learning and application of painting skills, sensing and providing feedback, utilizing motion data from experienced painters to guide novices

Innovation: The design is a fully new addition to the workplace and serves a different service than other existing products. Which also makes it difficult to foresee the adoption in practice. Research should focus mainly on acceptance and viability.

HEALTH SMART

Bodyguard

Vision: *"Design a device that creates a biofeedback loop that helps painters form better habits to reduce short-term discomfort (appeal) and long-term pain (risk). "*

Purpose: Designed to enhance human capabilities, the design provides empowerment by correcting poor body positioning, enhancing awareness, and posture monitoring.

Agent: Has an *enhancing* function. Utilizes data and AI through an IMU sensor and proprietary algorithms to predict and correct posture in real-time, going beyond human capability in monitoring and adjusting body positioning. There is also an app besides the wearable to provide feedback to the painter.

Innovation: The student takes a strategic approach towards painters with existing health problems who want to make a change, as well as budding painters who see the effects of poor posture around them and want to avoid it, aware of the fact that it isn't traditional enough to be accepted by everyone..

HEALTH CRAFTSMANSHIP UNCERTAINTY SMART

Guard AR

Vision: *"Make painting a healthier and longer-lasting profession by reducing strain on the painter's neck and doing this by discreetly implementing modern technology so that the feeling of craftmanship in painting is preserved."*

Purpose: The safety glasses are designed to reduce neck strain for painters by allowing them to look upwards without bending their neck. The interaction with the concept is designed to give the painter a lot of control, that they can make use of their craft without sacrificing their health and doing detailed work in areas not visible them.

Agent: Has an *enhancing* function, mainly vision while still standing in a healthy posture. The product is meant to enhance human function, and not be intrusive.

Innovation: The product is meant to be used as safety glasses, which painters use anyway, so it isn't meant to be an extra strain.The technical feasibility requires testing in practice.

HEALTH SMART

Intelliposture

Vision: *"Ensure a healthy style of work by decreasing physical strain as a result of bad posture during repetitive manual work while safeguarding the strong culture."*

Purpose: The wearable supports painters by enhancing awareness of bad posture through vibrations, and providing tips via an app, thus delegating tasks of posture monitoring to technology.

Agent: Has an *enhancing* function. The agent is a physical, wearable device, incorporating smart technology for posture correction. There is also an app for feedback and correction

Innovation: The use of existing sensors, actuators, and app technology makes the realization feasible within a short time frame. However, there will definitely be a long research process into acceptance prior to the realization. It is a fully new addition to the workplace, serving a new purpose in relation to existing tools.

Analysis

In relation to the design directions derived in the contextmapping, all points were to some extent considered by all students. Where most students predominantly focused on **health**, some brought their considerations of **craftsmanship** into the spotlight as well, aiming to adress both sides. One specific outlier within the directions was **uncertainty**. This was not a main focus for any of the concepts, only a consideration for a few. This could be attributed to the fact that the course is mainly directed at ergonomics, whereas this direction mainly shows opportunities in logistical and administrative areas. Some students managed to integrate aspects of uncertainty in their design where as others chose to focus more deeply in the other directions. A general overview of the positioning of the concepts (on the right) indicates that health showed the most promise for impact in the eyes of the students. However, it is important to recognize that not all concepts are directed into the same definition of 'health' and 'craftsmanship'. These are further explained on the next page.

Ensuring Health

Enhancing Craftsmanship

Embracing Uncertainty
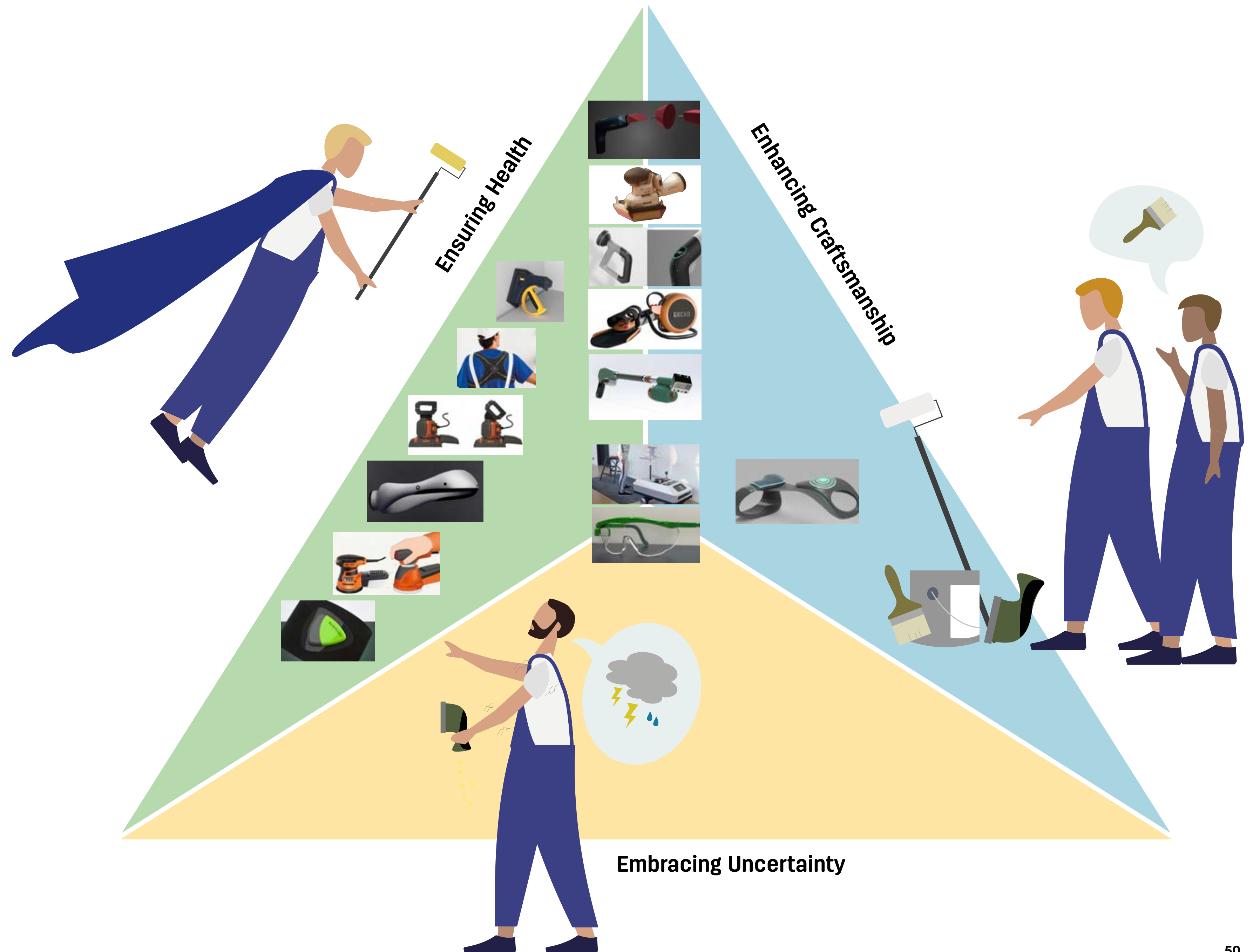
Purpose of the Concepts

Health

In the contextmapping research, it was evident that painters face diverse health issues, also reflected in the design concepts derived from the assignment. While all aspects were considered somewhat for each design, a predominant focus emerged on health. However, students varied in defining health, exploring different areas and concerns. One focal point was posture and physical strain, resulting in tools designed to either assist painters or delegate tasks to controlled tools, so they do not have to be in the unhealthy posture themselves. Another area emphasized safety and protection, addressing particles and fumes, integrated into sanders or as wearables. In many of the concepts it was clear that health was a gateway to craftsmanship and therefor the overarching goal in all health-related concepts was to prioritize safety and comfort without compromising the quality of work.

Craftsmanship

The goal in emphasizing craftsmanship was to expedite preparation for painters, enabling them to focus more on the act of painting and prolonging the enjoyment of their craft. Many concepts prioritize human touch and control, combining intricate detail work with automation for ease while ensuring the painter retains full control. Some concepts explore skill maintenance and learning, particularly for new entrants to the painting profession. Tools and wearables are envisioned to uphold tradition while incorporating technology for an enhanced painting experience.
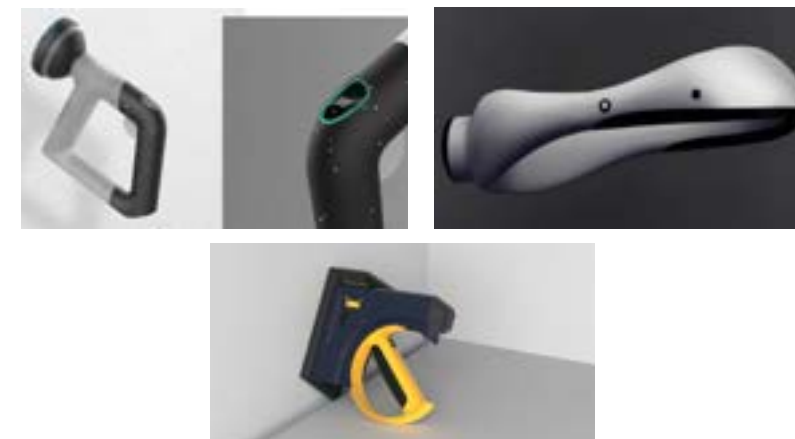
Uncertainty

Since uncertainty was not a main focus for any of the concepts, this will be further mentioned in potential and not in the analysis. However, it is important to acknowledge that the uncertainty aspect can be adressed by any of the concepts, with the addition of various sensors and AI models.
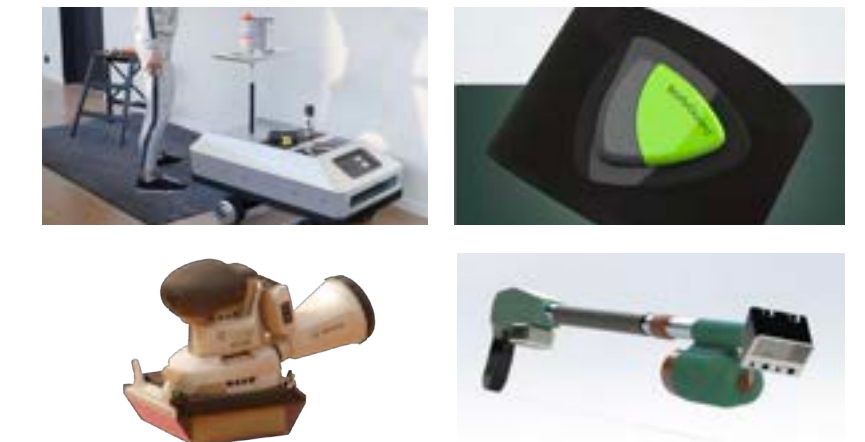
HEALTH / POSTURE
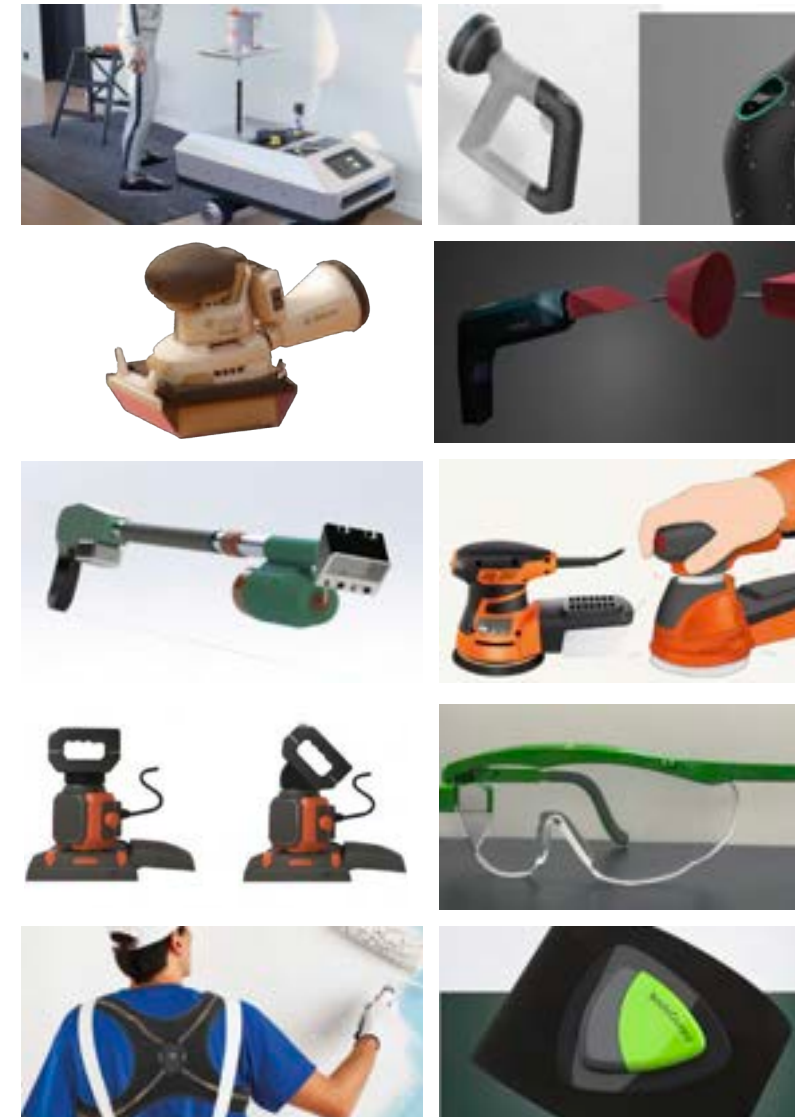
HEALTH / SAFETY

CRAFT / FASTER PREPERATION

CRAFT / (NEW) SKILLS

CRAFT / HUMAN TOUCH

Adoption of the Concepts

Feasibility Timeline

The feasibility of the presented concepts varies based on factors such as the level of smart technology integration and the extent of design and engineering research conducted so far. Some concepts with advanced technology may take longer to develop. Some students have outlined timelines for manufacturing, while others' plans are estimated and displayed on the right side of the page. The concepts on the earlier side of the timeline generally involve basic mechanic parts, while those further into the future may require more extensive research, particularly for technical/smart components. The course involved researching existing and developing technologies, making the concepts theoretically possible, but the practical timeline and technical feasibility remain uncertain, providing an approximation on the timeline. Making the choice of a desirable, viable and feasible product lies in the sweetspot of the technical feasibility and acceptance of the product.

Acceptance/Positioning

While students express optimism about the adoption of their products, the integration of technology into the traditional craft of painting may face challenges. Acceptance in part hinges on non-intrusive designs resembling existing products or offering enhanced value. On the right, the various concepts are classified based on their novelty: fully new, non-traditional replacements, and traditional replacements closely resembling current models. As the axis moves from left to right, the resistance to adopt the product may increase, due to the unfamiliarity of the product. Some students strategically target niche markets to enhance viability, however when looking at the business side of the adoption, this too has its pitfalls. Even if the product is desirable by the painters, the costs may be too high to become a part of the workplace. The question of striking the right balance of innovation and acceptance remains, but many products exhibit potential for future integration into the workplace.

Conclusion of the Conceptualization

The integration of smart elements in the realm of house painting has the potential to enhance key aspects of the craft of painting. With various concepts designed by the students, a new future for the painting profession is visualized, where technology takes the lead while aiming to keep craft and tradition in the forefront.

The incorporation of health-focused technologies not only prioritize the well-being of painters but also provides them with "superhuman capabilities", enhancing their senses and overall performance on the job.

Moreover, the infusion of smart tools into craftsmanship elevates the quality of work and significantly boosts efficiency, showcasing the symbiotic relationship between technology and traditional skills. These do grasp attention as they aim to integrate technology without taking the control away from the painter, and therefore safeguarding the tradition.

Lastly, in addressing uncertainty, the smart elements could provide invaluable support by aiding painters in navigating unexpected circumstances, offering insights, empowering them to make informed decisions amidst external conditions. This aspect was not focused on in the prototyping of various concepts, however is important to consider in the addition of various functions in future design research on the matter.

Collectively, these themes not only empower painters with the tools and capabilities needed to thrive in a dynamic and unpredictable environment, but als redefine the landscape of house painting, making the craft more appealing for the next generation.

OPPORTUNITIES

Identifying Opportunities

In a workshop with Muzus, TU Delft and SUSAG, the concepts created by the students of the course Advanced Concept Design (ACD) were further analysed and preferences were identified by SUSAG for further research. These were based on various points as will be mentioned in this chapter, by pinpointing the important aspects of a promising concept and how the top 3 concepts chosen by SUSAG comply with these requirements.

Other Contexts

Other concepts were also taken into account during the workshop. In addition to the students of the ACD course which were highlighted in the conceptualization phase of this project, other students also played a role in creating concepts and idea's for the sustainable deployment of painters. These took place in various contexts, and resulted in other innovative opportunities which show promise in its potential and also bring up the possibility to compare and combine various similar ideas.


Advanced Concept Design (ACD)

As mentioned earlier in the conceptualisation, the students of this course mainly focused on the mechanics and ergonomics of design. Smart agents were not a requirement for this group of students, and the priority was form over interaction.

Interactive Formgiving (IF)

In the Interactive Formgiving course, four student teams developed a concept for a smart agent by means of design fiction. Through the medium of video, these teams breathed life into futuristic visions of smart agents, all without requiring developing any technology. Crafting these fictional narratives allowed students to explore how such technology could seamlessly integrate with existing equipment, ensuring that intelligent behaviors complement rather than overshadow human actions. Furthermore, they examined how these agents could be effectively utilized in their professional practice. These videos facilitated discussions within our SUSAG stakeholders and also served as inspiration for students in the ACD course.
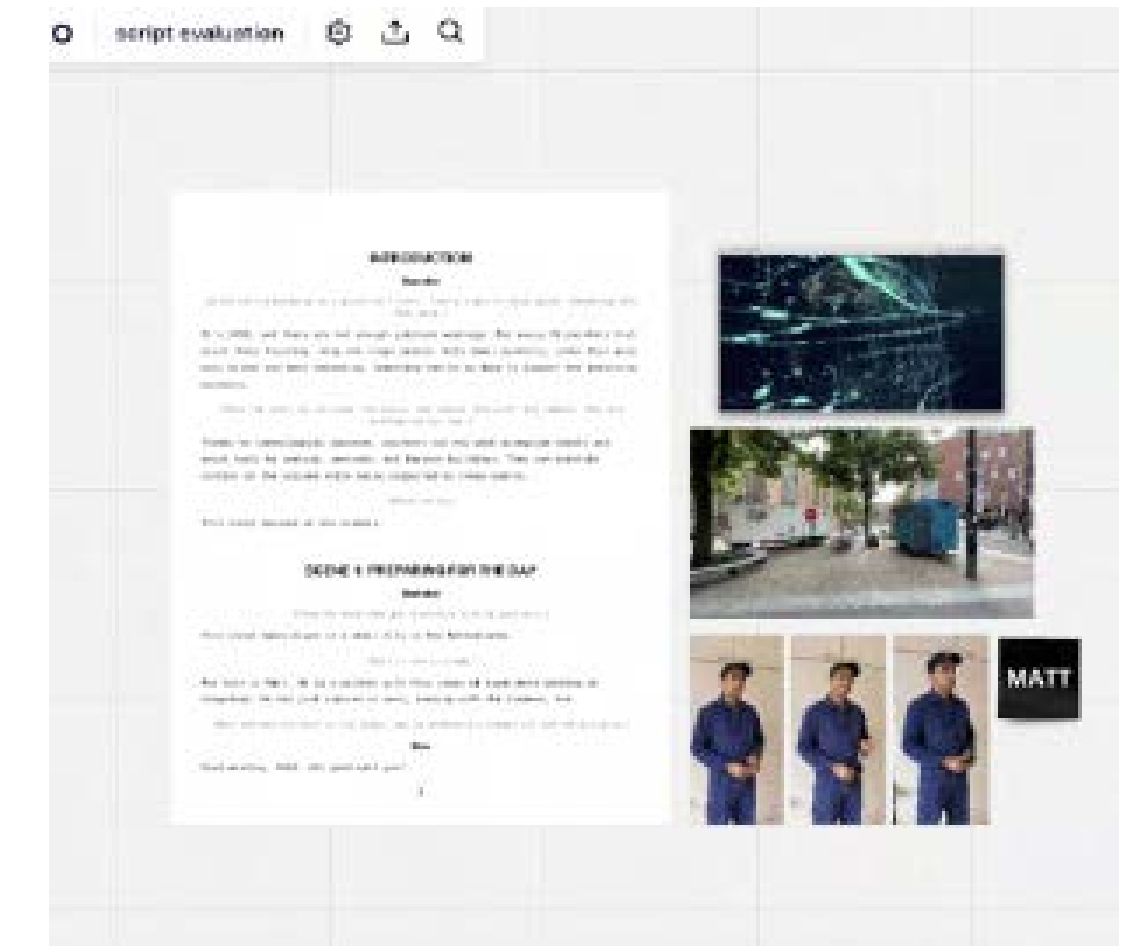
Graduation Thesis

A Master student from TU Delft Design for Interaction Master program also conducted a 20 week graduation project on the topic. The project focused on developing design guidelines for painter-agent collaboration. Through the creation of a design fiction scenario that unpacked the concepts of agent authority, autonomy, and control for this particular context, the project revealed the considerations of painters for the integration of agents in their profession. From these discussions, design guidelines were developed for each of these three themes.

(Link to the report: https://repository.tudelft.nl/islandora/object/uuid%3Abf969926-0bf3-4412-9d2f-914e0166daf3)

Chosen concepts from the ACD course

A total of 7 concepts were chosen for further research, with the first 3 being the most exciting to further prototype. Ideas were also brought up to combine concepts from the ACD course, as well as concepts from the other courses. The following concepts serve as the base for innovative ideas that were attractive for SUSAG to further research/invest in.

1. Brisa

This concept offers an easy solution to the bulky protective gear that painters have to use. As it replaces many of the uncomfortable equipment it offers a great unintrusive solution to an evident problem. The combination of this and another concept created in the Interactive Formgiving course showed the most promising result. The only issue mentioned with this concept was the conformity to rules and regulations, which will be further researched.

2. Tape it Easy*

This concept was found to be basically market-ready, with a well thought out concept that addressed an evident problem in the workplace, helping with health concerns as well as efficiency. It creates room for the painter to carry out their craft without compromising health and quality. This product was seen as a "ready product" without need for smart agents, it wasn't seen as much of an innovation as the others are. The * in the title depicts that this is not technically a part of the top 3 that will be further researched with prototyping in

3. Gecko

This concept was found to "tick all the boxes". It was by far the most interesting sanding machine, by giving an unexpected original spin, to the other sanders focusing on health. This one was directed at enhancing the craft and control of the painter, considering the health sacrifices that are not actually necessary. It isn't only beneficial but also interesting in form, which allows for a new novel addition to the workspace, giving the idea of "I look cool using this."


4. Robot Cart

This was one of the most interesting concepts due to the potential of the functions that can be added. It showed a lot of promise for AI to be integrated, as well as many new functions, to improve health,

aid with craftsmanship and even helping the painter in unpredicted situations. This was also a concept that could be combined with others, especially to address uncertainty and planning which other concepts do not.

5. ACV Sanding Machine

The concept seemed to be the most interesting of all the sanders as it uses an interesting mechanism to decrease vibrations. However, there were also ideas in which many of the designing sanding machine concepts were combined to reach the overarching goal of ensuring health.
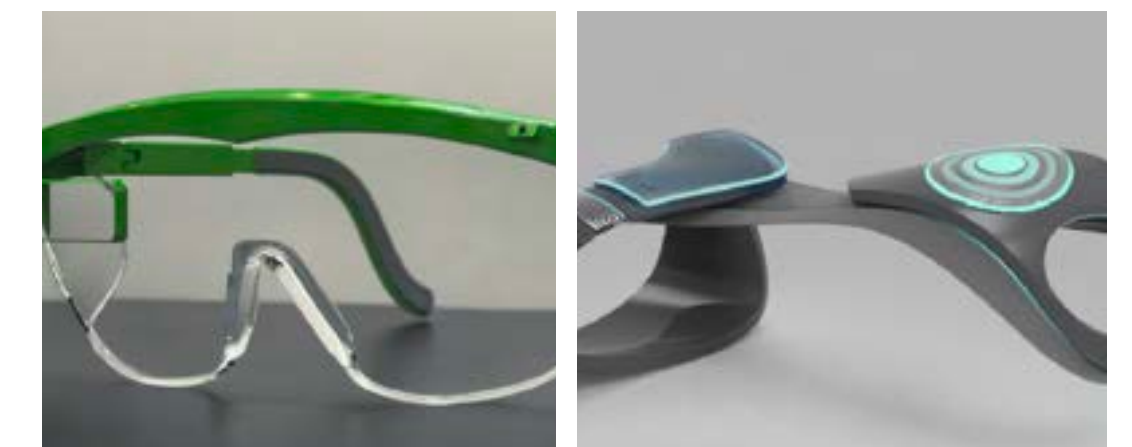
6/7. Guard AR & Strokebeat Combination

These 2 concepts were chosen mainly for their form, rather than their purpose. The purpose of both did not seem to address an evident issue, however the combination of both in form, posed a lot of potential to be the embodiment of other important ideas.

What makes innovation promising?

During the analysis of the concepts, a few points came up, such as the feasibility and the adoption potential of various concepts. In conversation with SUSAG, it was clear that even though these may be the main building blocks of a promising innovation, the sector itself has points to adress as well. Yes, the fact is that the concept should be feasible to produce and have high potential to be accepted by painters, but it does also have to serve an actual purpose and be not only desirable to the painters themselves, but the employers. The members of SUSAG mentioned that innovating for the sake of innovating has failed previously (with exoskeletons being given as an example) and expressed the need for clear cut guidelines for what they should be investing in to increase sustainable deployability.

So, the question is what makes an innovation promising in the context of painters? There are multlple requirements to be considered.

Health and Safety

Health is a requirement that may not be on the backburner. For any and all integration into the workplace, a concept must be well considered in the aspect of health. Increasing health benefits is a plus, but the main priority is to avoid deterioration of any kind. If a product has a negative effect on health or hinders health practices, it should be adjusted.

Desirability

The concept should be attractive to the painter, they should want to use the product/device. It should give the painter the feeling of "look at me go!" and make them feel excited to be using it. The appearance should also be attractive to new generations, creating a buzz that this new and cool concept can be used only if you become a painter.

Sense of Control

It should be easy to use, and not hinder any current practices. The painter should have all control in how the product functions and the result that it delivers. It should not force

painters and/or stand in the way of current practices. The product should consider craftsmanship and tradition, and address this accordingly.

Purpose

The concept should address an existing issue/situation. The purpose should be either to increase efficiency and enhance, or decrease the difficulty/intensity of a task.

Viability

The product must be desirable to the employers and manufacturers. There must be a clear profit to be obtained for it to be considered in production. It should serve a broad enough spectrum of issues that it becomes worth investing in. For example, even though health is crucial, any product that focuses solely on health is not considered enough as it will not serve a broad enough purpose in practice to be viable in the cost-profit balance.

Compliance

There are multiple rules and regulations in the painting sector, some are about safety in the workplace and others about sustainable deployability of the painter. Any concepts designed for painters must comply with these regulations.

Guidelines for Evaluating Promising Innovations

While an innovative design concept may initially seem promising, a closer examination may reveal critical aspects that have been overlooked. To address this, six criteria have been established to provide a structured framework for assessing and rating innovative concepts in relation to their potential impact on painting practice. Each criterion comprises multiple questions aimed at evaluating various aspects of the concept. The tool works as follows: A concept is assessed against each criterion using a scale of 1-5, with 1 indicating a less favorable evaluation and higher scores indicating greater promise. These scores are then utilized to generate a spider chart, facilitating easy comparison, and highlighting areas for improvement or reconsideration in terms of fulfilling their promise.

Health and Safety

1. Would the concept improve the health of painters or enhance their safety while carrying out work?
2. Does the concept avoid introducing any new health or safety risks?

Desirability

1. 1. Would the concept be enjoyable to use, such as being attractive, exciting, cool, or fun?
2. Is the concept easy to use, characterized by simplicity and understandability?
3. Is the concept appealing to both current and new generations of professionals?

Sense of Control

1. Do painters maintain control over their actions when using the concept?
2. Do painters retain the freedom to make decisions while using the concept?

Purpose

1. Does the concept offer a solution to a current pressing problem?
2. Does the concept avoid creating any new problems?
3. Would the concept be considered meaningful rather than merely a superficial addition?

Viability

1. Can the concept be produced in a cost-effective manner?
2. Does the concept fulfill a clear market niche, satisfying the needs of employers, manufacturers, and investors?

Compliance

1. Does the concept comply with existing rules and regulations?
2. Would the concept provide a convincing case for the need to change existing rules and regulations?
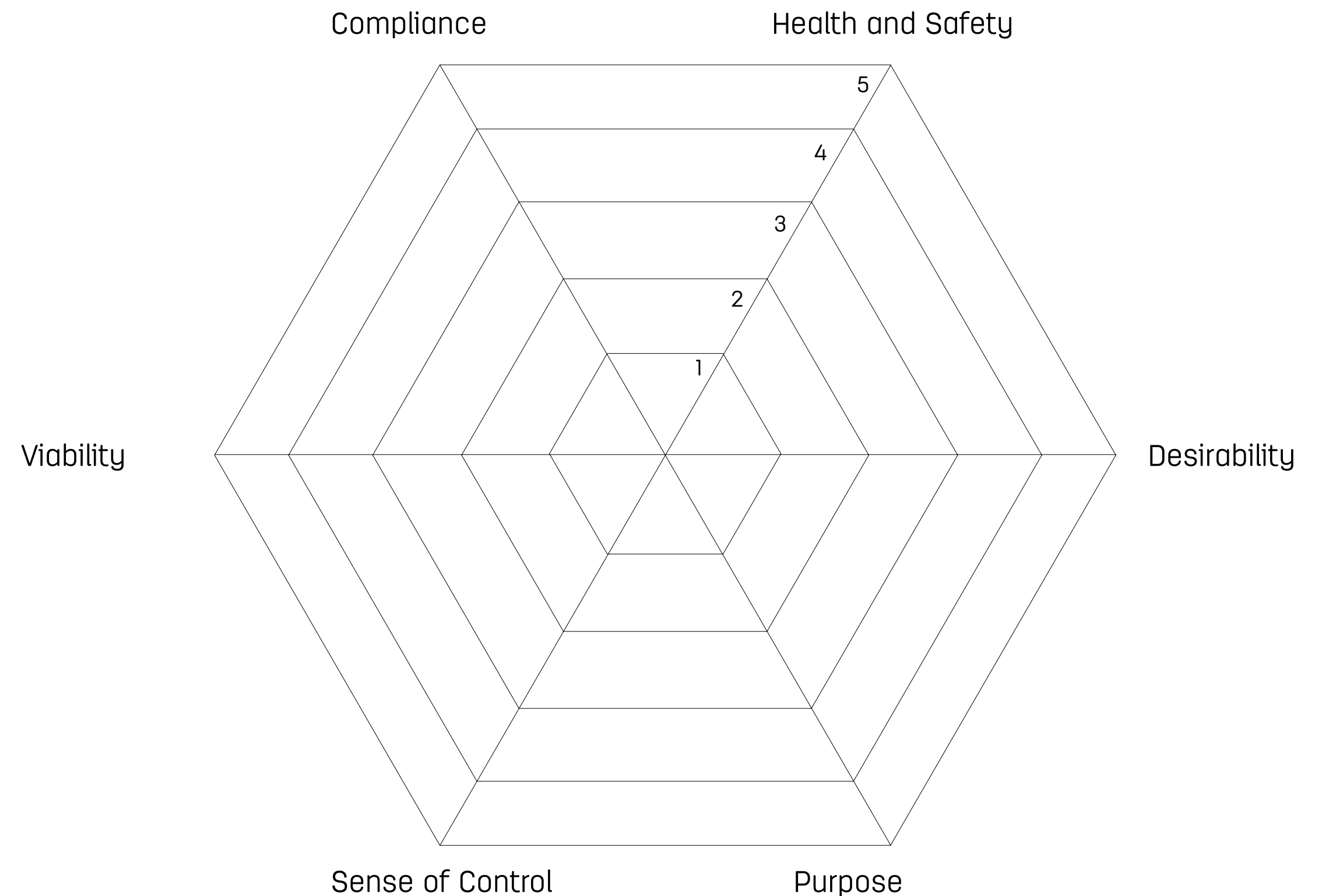
The Guidelines in Use

When scoring, each line of the spider chart represents a score from 1-5. Each score is plotted on the corresponding line of the criterion, and then lines are drawn between each to create a shaded area contained by the plots.

For the purpose of demonstrating the use of the chart, 2 hypothetical concepts have been used. These were scored for each criterion, plotted on the spider chart and the area within was shaded. When comparing the 2 concepts, it is clear the concept 1 (on the left) is less promising than concept 2 (on the right). What to look out for in assessing the chart is a large, balanced surface area on the chart.

The scores do not all have to be extremely high. We are looking for balance, which also means that if one criterion scores incredibly high, and another incredibly low, this concept is also not considered promising until a new iteration is made to address the shortcomings. There may still be potential in the concept if one or two criteria score low, and therefor there may be benefit in a reiteration.
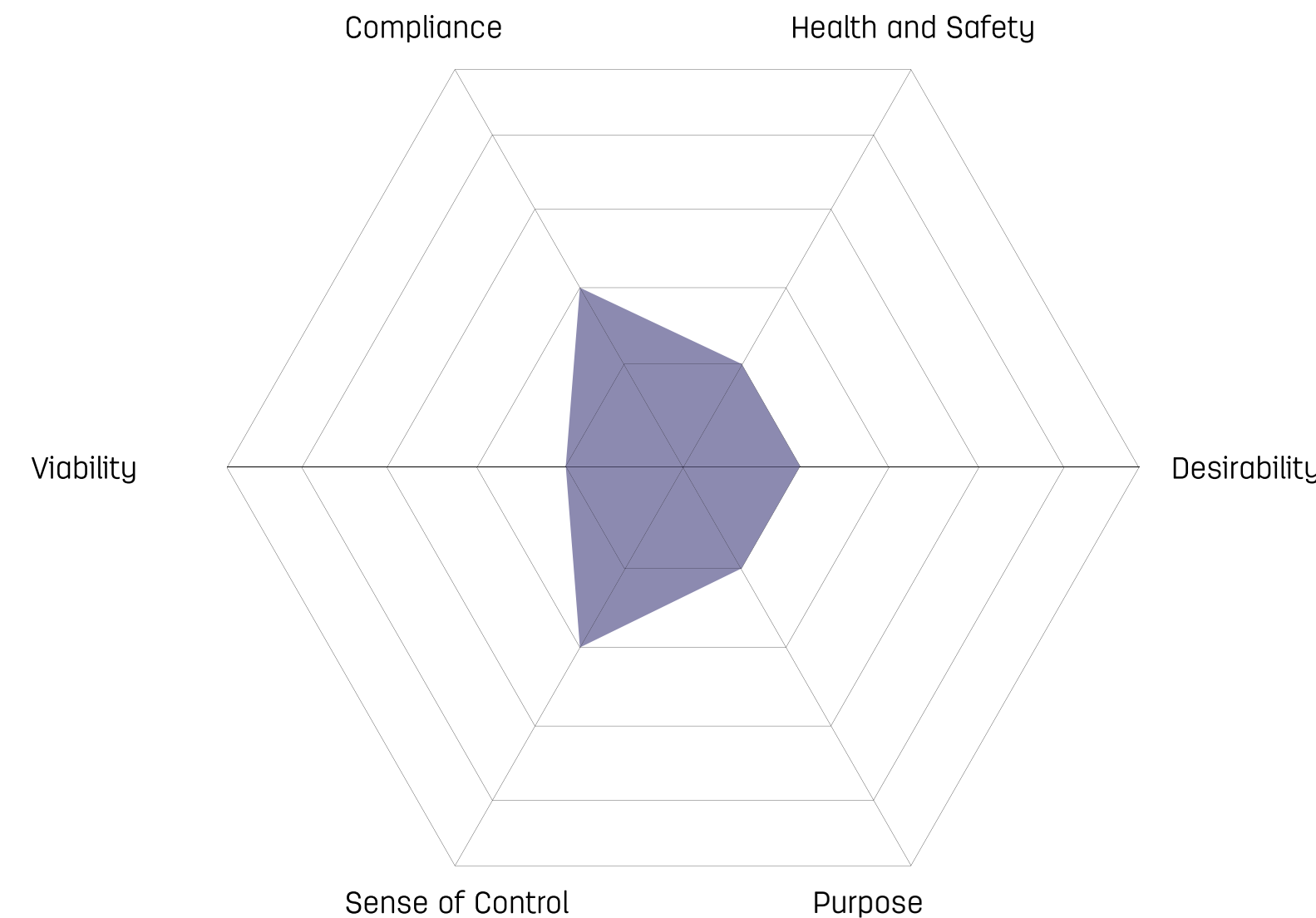
Example Scores Concept 1:

Health and Safety - 1 / 5

Desirability - 1 / 5

Purpose - 1 / 5

Sense of Control - 2 / 5

Viability - 1 / 5

Compliance - 2 / 5

Not a Promising concept
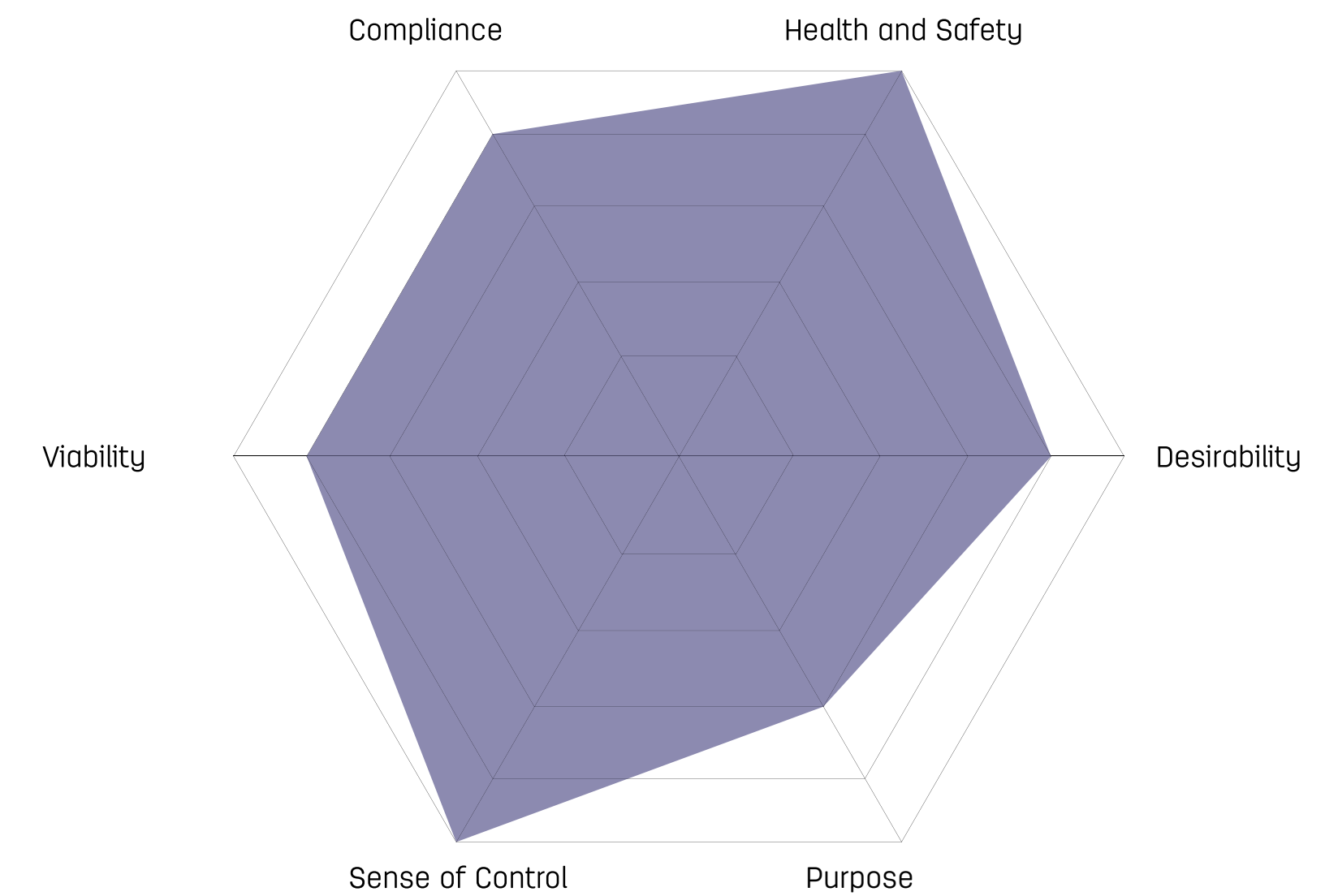
Example Scores Concept 2:

Health and Safety - 5 / 5

Desirability - 4 / 5

Purpose - 3 / 5

Sense of Control - 5 / 5

Viability - 4 / 5

Compliance - 4 / 5

Promising concept

Conclusion of Phase 1

The culmination of contextmapping research, trend analysis, and insights into the painting profession has revealed three design directions: **1. Ensuring Health, 2. Enhancing Craftsmanship, and 3. Embracing Uncertainty**, which after conceptualisation and analysis still ring true.

Tailored to meet diverse needs, these opportunities aim to support sustainable deployment for painters. Transitioning from the research conducted by Muzus and TU Delft, the master's students took charge, crafting concepts that target these identified opportunities. These concepts, as well as examples from other design contexts showed that the entrance of technology and smart agents into the work practice of painters is not only plausible, but desired.

The analysis showed that innovation for the sake of innovation was not viable. Therefore a series of guidelines were created to test with the existing ideas, as well as any future innovation opportunities that may come across the table. The future of the painting profession looks bright and smart agents show promise to lead the way in increasing the sustainable deploability of the painters.

MUZUS

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