Research document

In collaboration with Supplydrive and TNO

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1 Introduction

1.1 Context

The primary goal of this project is to create a demo/prototype of working instructions that is tailored to the experience level to the employee assembling a product. These dynamic working instructions aim to improve the overall learning capabilities of an assembly worker whilst keeping the time spend assembling the product to a minimum. The product in this project is a 3D model of a bicycle, serving as a placeholder for other products. The bicycle is a detailed example, but the solution must be scalable for multiple products. Ultimately, this will result in a template.

Because it is a placeholder, it is crucial for DataBridge to align with Supplydrive's vision of creating solutions that can be applied to various scenarios with minimal effort. Next to this prototype Supplydrive would like to receive DataBridge its advice on how to further improve this process of product assembly. This advice is to be based on DataBridge its research results and will could be used to create future projects.

1.2 Research Questions

1.2.1 Main Question

How can Supplydrive create dynamic work instructions, tailored to operator skill levels, to improve the quality of service provided to clients?

1.2.2 Sub-questions

1. What is the current situation of dynamic work instructions at Supplydrive?
2. What is the desired situation of dynamic work instructions at Supplydrive?
3. How can operator skill levels be defined, measured and assigned?
4. How can a template system be used to create work instructions for the assembly of a miniature bike?
5. How can a template system for product instructions be developed to accommodate varying skill levels?

1.3 Objectives

The objective of this project is to create a skill matrix that describes the different skill levels involved in assembling a product. This product could take different forms, but for this project it is a 3D model of a bicycle. DataBridge must then assess an employee's skill level, based on data that is accessible through SCSN, to give that specific employee instruction that is tailored to their experience. These steps aim to keep the assembly time of the product to a minimum whilst increasing the learning capability of the employee assembling the product. This project also serves as a template to be used for other products that need to be assembled instead of a 3D rendition of a bicycle.

2 Research Approach and Patterns

During the research, the DOT Framework is used. This framework employs various research strategies, ultimately allowing for triangulation. Within the DOT Framework, five different strategies are applied. Triangulation in this context requires the use of at least three of these strategies to investigate a sub-question. By utilizing diverse research methods, the validity and credibility of the results are ensured.

For each sub-question, different strategies and methods from the DOT Framework are used.

The 'Library' component involves researching results, online examples, and literature. 'Field' focuses on exploring the application context, emphasizing end users and their needs. 'Lab' represents testing, whether for concepts or final versions. 'Showroom' includes tests conducted in collaboration with stakeholders or experts, comparing the product to previously developed products. 'Workshop' focuses on possibilities such as prototyping and design. The use of these diverse methods within the DOT Framework ensures an in-depth and reliable study (Van Turnhout, n.d.).

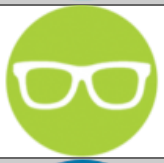
Sub question 1: What is the current situation of dynamic work instructions at Supplydrive?

Table 1: Used researchmethodes first sub question

Strategy	Method	Elaboration
	Interview	An interview will be conducted with Stijn Murrer and Jeroen van Oosterhout to gather more information about MKG and Azumuta, as well as the current situation of these tools.
	Brainstorm	Brainstorming is chosen because it always generates new ideas while simultaneously deepening the understanding of the current situation. Additionally, bottlenecks frequently emerge during these sessions.
	Literature Study	A Literature Study is necessary to examine the terms encountered during the investigation of the current situation. The tools MKG, Azumuta and SCSN are researched.
	Joker: IST	As a Joker, an IST-Process is selected. DataBridge is eager to understand what exactly is in place now. A process provides an excellent way to map this out.

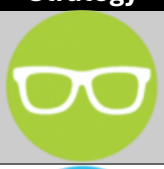
Sub question 2: What is the preferred situation of the solution?

Table 2: Used researchmethodes second sub question

Strategy	Method	Elaboration
	GAP analysis	A GAP analysis is conducted to determine the gap between the current situation and the ideal situation of the project.
	Explore user requirements	Establishing requirements based on the needs of Supplydrive helps track progress while also ensuring clarity on what needs to be done.
	Requirements prioritization	The requirements are prioritized to identify which aspects of the project hold the highest importance.
	Available product analysis	An analysis is conducted to compare other tools alongside MKG and Azumuta.
	Joker: SOLL	As a Joker, a SOLL-Process is chosen. By visualizing an ideal process of assembling a bike, the desired outcome becomes clear.

Sub question 3: How can operator skill levels be defined, measured and assigned?

Table 3: Used researchmethodes third sub question

Strategy	Method	Elaboration
	Good and bad practices	Researching good and bad practices helps clarify what is feasible and what is not, providing a clearer of how DataBridge can define operator skill levels.
	Prototype	A prototype is created to make it more visual of what is possible around the operator skill level definition.
	Peer review	A peer review is conducted to present the current progress to Supplydrive and gather feedback.

Sub question 4: How can a template system for product instructions be developed to accommodate varying skill levels and be applied to the assembly of a miniature bike?

Table 4: Used researchmethodes fourth sub question

Strategy	Method	Elaboration
	Usability test	A usability test is conducted to evaluate the effectiveness of the dynamic work instructions and to determine whether the different instruction levels are well-designed.
	Product review	A product review is performed to evaluate whether the prototype meets the requirements. This is done through contact with the product owner. Also the ‘guide to Azumuta’ is evaluated.
	Prototype	A prototype featuring dynamic work instructions for the 3D bike is being developed, providing a clear example of how such a product could function.

3 Research Outcomes

Here the outcome of the different research questions will be analysed and answered.

3.1 What is the current situation of dynamic work instructions at Supplydrive?

Within this part of the document, one can find the interview, a brainstorm afterwards and a literature study into relevant software. Also, an IST process is made.

3.1.1 Interview

The interview with Jeroen van Oosterhout (TNO) and Stijn Murrer (Supplydrive), in collaboration with DataBridge, provided valuable insights into digital work instruction platforms, their classifications, and their integration with systems like MKG and Azumuta. This interview has been paraphrased and summarized.

Digital Work Instruction Platforms

The market for digital work instruction platforms is vast, with significant variations in functionality. While most platforms follow a stepwise instructional approach, their capabilities can differ significantly ranging from basic implementations to highly sophisticated solutions. Azumuta is positioned in the higher segment due to its extensive connectivity, data logging and workflow automation features. Another comparable platform with multi-level instruction capabilities is Arkite.

Market Trends and Limitations

Most platforms define instructions on one, two, or three levels, primarily due to programming simplicity and market demand. While multi-level instruction systems exist, they introduce complexity that is not always justified by market needs.

Integration of MKG and Azumuta

MKG, primarily used in the metal industry, manages production-related information, while Azumuta is used closer to the operator level. Their integration relies on XML-based data exchange through Supplydrive, ensuring smooth order management. The decision to handle skill-level management within Azumuta rather than MKG aligns with each tool's intended purpose.

Product Passport and Traceability

The concept of a product passport is gaining importance. Incorporating material certifications, carbon footprint data and batch tracking. However, personal information (such as the specific employee responsible for assembly) remains a legal and ethical grey area.

Skill-Level Determination

Skill levels are typically managed via a skill matrix. They are updated or improved through training or manual increase. Automated skill progression remains rare, though research at TNO has explored adaptive operator support using Cognex cameras to measure task execution accuracy.

Conclusion

The interview gave us a clearer understanding of the digital work instruction platform landscape, including the classification of platforms like Azumuta and Arkite, and their integration with systems such as MKG and Ridder iQ. We also gained insight into current market limitations, trends in skill-level management, and the different parties and experts involved in overlapping projects. This broader perspective supports more informed decisions when developing our solution.

3.1.2 Brainstorm

DataBridge conducted a brainstorming session to organize the currently available information. This information has been visually represented in a mind map, providing a clear and structured overview. The mind map serves as a tool to enhance the understanding of the information.

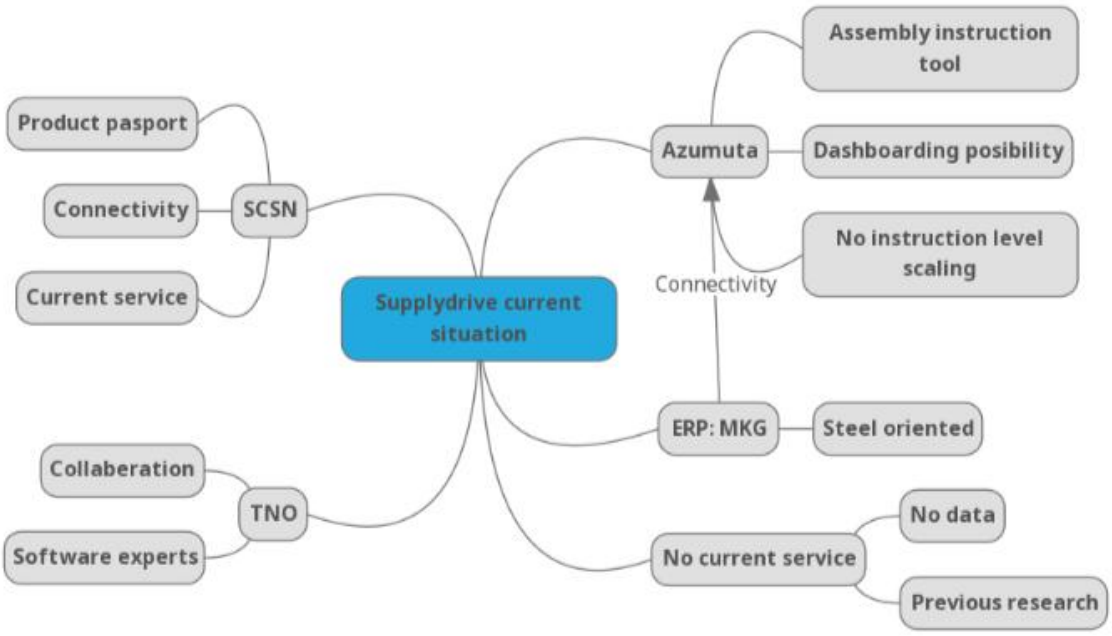


Figure 1: Mind map current situation Supplydrive

Figure 1 illustrates a mind map of the current situation at Supplydrive regarding the improvement of work instructions. The brainstorming session revealed that there is currently not a product or foundation to build upon. There is a connection between Azumuta and MKG, but nothing beyond that. DataBridge has the freedom to explore the best methods for delivering tailored work instructions within Azumuta.

Conclusion Brainstorm:

The conclusion of the brainstorming session is that there are already two available tools: the ERP system and the instruction platform Azumuta, which are connected. Apart from examples within Azumuta, there is little else to start with. Aside from this, one the developer is limited to the boundaries set within Azumuta, this might propose a threat. This gives DataBridge freedom to explore and determine the best approach for delivering tailored work instructions.

3.1.3 Literature study

Within this part of the document, one is able to find the research done into all necessary software, together with additional needed.

What are work instructions?

As the main purpose of Azumuta is to create work instructions, one needs to identify what a digital work instruction is. Digital work instructions are digital versions of traditional work instructs made on paper. They create the availability to transform the paper version into a dynamic and interactive tool that can guide workers. The complexity of these guides differs, making it usable for training and for complex processes. It does this by step-by-step directions, visual aids and added, contextual information (Howell, 2024).

What is the future of work instructions?

With the rise of Virtual Reality (VR) and Augmented Reality (AR), the future of digital work instructions is set to reach new levels of realism and interactivity. These technologies, initially driven by the gaming industry, have become increasingly affordable and accessible, opening significant potential for industrial applications, particularly in training and education. Although not yet possible, Azumuta could be used to realise this in future updates if this appears to be a more effective way of giving instructions.

One of the primary advantages of VR and AR in industrial training is their ability to provide intuitive navigation and immersive experiences. Unlike traditional 3D training applications that require users to navigate using a mouse and keyboard, VR allows users to move naturally within a virtual environment. This intuitive approach helps users, especially those unfamiliar with gaming or 3D applications, to focus on the learning content without being distracted by the navigation process.

However, creating VR content, especially animations for assembly tasks, remains a significant challenge. Most companies possess 3D data in the form of Computer Aided Design (CAD) drawings but transforming these into interactive VR training modules requires substantial time and expert knowledge. The process involves creating animations to visualize working steps and programming the logic of the training application.

To address these challenges, a prototype for a VR-supported learning and training application has been developed, focusing on simplifying the content authoring process. This prototype introduces an "authoring-by-doing" approach, where an expert performs actions in the VR environment. These actions are recorded and can be replayed later as semi-transparent "ghost" animations. Trainees can then follow these recorded instructions interactively, mimicking the expert's actions step-by-step. This method aims to accelerate content creation for industrial VR-learning scenarios and promote the adoption of VR technologies in industrial applications (Wolfartsberger & Niedermayr, 2020).

In conclusion, the integration of VR and AR into digital work instructions holds great promise for the future of industrial training. By simplifying the content creation process and providing intuitive, immersive experiences, these technologies can enhance the efficiency and effectiveness of training programs, ultimately driving gr eater adoption in the industrial sector.

What is Azumuta?

Azumuta is a comprehensive software platform designed to digitize and streamline shop floor operations in the manufacturing industry. Here are some key features and benefits of Azumuta:

Key Features:

1. Digital Work Instructions: Provides up-to-date, interactive work instructions that include videos, images, and 3D files, making it easier for operators to follow procedures accurately.
2. Quality Management: Enhances quality assurance processes with digital checklists, audits, and real-time data capture.
3. Training and Skill Management: Facilitates quick onboarding, retraining, and on-the-job training through a skill matrix and training modules.
4. Data Integration: Seamlessly integrates with ERP systems to keep product orders and work instructions in sync.

Benefits:

- Operational Efficiency: Automates and optimizes various tasks on the shop floor, improving overall efficiency and productivity.
- Compliance and Safety: Helps meet regulatory requirements and ensures safety standards are maintained.
- Workforce Agility: Empowers frontline workers by providing them with the tools and information they need to make informed decisions and drive innovation.

Azumuta aims to transform traditional manufacturing practices into a more efficient, digital-first approach, making it an asset for modern factories (*Unlocking Manufacturing Excellence: Discover Why Azumuta Leads the Industry*, 2025).

Usage of Azumuta

This part will cover the different uses for Azumuta based on the key features within. All information is retrieved from specific parts of the knowledge base supplied by Azumuta (*How to Use Azumuta - Azumuta Knowledge Base*, 2025).

Digital work instructions

Azumuta is mainly used as a digital work instructions platform. It enables to overseer of a production line to create detailed work instructions including features as:

1. Visual Work Instructions: Create rich, step-by-step instructions using multimedia elements like videos, graphics, and 3D images to ensure clarity and effectiveness.
2. User-Friendly, No-Code Platform: Azumuta's no-code platform allows anyone to create and manage work instructions effortlessly, regardless of their technical expertise.
3. Drag-and-Drop Multimedia Integration: Easily enhance instructions by adding images, videos, and 3D models using a simple drag-and-drop functionality.
4. Intelligent Variants & Templates: Manage multiple product variations within a single set of instructions and use a library of reusable templates to streamline document creation.

5. Revision History & Approval Flow: Keep track of changes and ensure that all updates go through an approval process to maintain accuracy and compliance.
6. Multi-Language Support: Provide instructions in multiple languages to cater to a diverse workforce.
7. Connectivity & Access: Seamlessly connect with other systems and ensure that work instructions are easily accessible on the shop floor.
8. Continuous Improvement: Utilize feedback and data to continuously improve work instructions and processes.

These features help creating a user-friendly interface for both the operator as the team leader (*Digital Work Instructions: Everything You Need to Know - Azumuta*, 2024).

Metaal Kennis Groep (MKG):

Enterprise Resource Planning (ERP) systems are essential for streamlining operations across industries by integrating business processes into a unified platform. MKG, the focus of this study, is an ERP system specifically tailored to the unique demands of the steel and production industry (Admin & Admin, 2024).

To meet the specialized needs of manufacturers, processors, and distributors, ERP systems like MKG address several key areas:

- Material & Inventory Management: Tracking raw materials, semi-finished goods, finished products, batch tracking, stock optimization, and automatic reordering (Van Enkhuizen, 2025a).
- Production & Process Management: Scheduling and tracking production orders, integrating with machines (e.g., CNC equipment), and managing scrap and yield (Admin & Admin, 2024).
- Sales & Order Processing: Automating quotations and pricing, tracking sales orders, and integrating customer relationship management (CRM) systems (Admin & Admin, 2024).
- Purchasing & Supplier Management: Vendor evaluation, price comparison, and procurement automation (Van Enkhuizen, 2025a).
- Logistics & Supply Chain: Route planning, delivery tracking, and calculating freight costs (Van Enkhuizen, 2025a).
- Finance & Accounting: Costing based on weight and wastage, profitability analysis, and ensuring compliance with tax regulations (Admin & Admin, 2024).
- Quality Control & Compliance: Material testing, traceability, and managing corrective actions (Van Enkhuizen, 2025a).
- Business Intelligence & Reporting: Providing real-time dashboards, custom reports, and forecasting tools (Admin & Admin, 2024).

MKG is particularly adept at managing financial, production, and administrative processes. Its functionalities include flexible setups for financial management, automated bookings, and support for periodic adjustments (MKG, n.d.). The system's search capabilities allow efficient data retrieval, while seamless process integration ensures smooth transitions from production to administration (Van Enkhuizen, 2025a).

External software integration with MKG, such as Azumuta, is feasible and aligns with Industry 4.0 principles (Admin & Admin, 2024). These integrations enable real-time synchronization and traceability through various approaches:

- API and Webhook Integrations: Facilitating real-time data sharing between systems.
- Middleware Platforms: Bridging data fields and ensuring compatibility.
- Customization: Establishing protocols to align business processes effectively (Van Enkhuizen, 2025a).

In summary, MKG is a specialized ERP system designed to streamline processes across material management, production, sales, logistics, finance, and more in the steel industry. Its integration capabilities, such as APIs and middleware platforms, empower organizations to leverage Industry 4.0 principles for operational excellence. The system offers versatile options for optimizing workflows and driving long-term efficiency (Admin & Admin, 2024; MKG, n.d.; Van Enkhuizen, 2025a).

Smart Connected Supplier Network:

This section of the document provides an explanation of the Smart Connected Supplier Network (SCSN), based on research.

The Smart Connected Supplier Network offers a digital solution that automates data transfer between customers and suppliers. By integrating directly with ERP systems, SCSN simplifies and optimizes the processing of business documents such as sales orders, invoices, packing, bills of materials and supply chain data.

One of the benefits of SCSN is the automation capabilities, which streamlines business processes and reduces the risk of manual errors. The network is designed for seamless integration, ensuring compatibility with existing systems and standards. Additionally, cost savings are an advantage, as automated data exchange reduces labour-intensive tasks and minimizes errors, lowering operational expenses (*Smart Connected Supplier Network*, 2022).

How SCSN Works

The Smart Connected Supplier Network facilitates automated and secure data exchange between companies through two components:

1. Messaging Standard: SCSN utilizes the Universal Business Language (UBL), an internationally recognized format for structuring business data.

2. Infrastructure: The network is built on the four-corner model, which allows for flexible and secure data exchange without a central authority controlling all the information. Data is shared through independent service providers, ensuring companies retain full control over their own data—an approach known as data sovereignty.

Additionally, the network is enhanced by International Data Spaces (IDS) technology, which guarantees secure data sharing without compromising privacy or ownership (*Hoe SCSN Werkt*, n.d.).

The Four-Corner Model

Over the years, companies have used different methods to exchange data. Initially, businesses established direct connections with each other, known as the two-corner model. While effective, this method was costly and difficult to scale, as each new connection required custom integration.

To address this, the three-corner model introduced a central IT provider acting as a middleman, allowing companies to connect just once instead of managing multiple connections. However, this created a dependency on a single provider, limiting flexibility and increasing risks of a data monopolization.

SCSN adopts a new approach with the four-corner model. In this system multiple independent service providers operate within a shared network, ensuring that businesses can exchange data regardless of which service provider they use. This structure not only prevents monopolies but also enhances security and ensures that companies maintain control over their own data (*Hoe SCSN Werkt*, n.d.).

Comparison to Telephony

The way SCSN works is like how telecommunication networks operate. When people make phone calls, they communicate freely, regardless of their provider. This is possible because all telecom providers are part of the same system.

Similarly, within SCSN companies can exchange data regardless of which provider they are connected to. This is made possible by a shared address book, which allows businesses to find and communicate with others and a standardized infrastructure, ensuring that all service providers are interconnected (*De Voordelen van SCSN*, n.d.).

Conclusion

SCSN is transforming data exchange in the manufacturing industry by offering a solution that is both scalable and future-proof. By using open standards and a decentralized network, SCSN enables companies to connect, collaborate and innovate without barriers. With its ability to streamline operations, reduce costs and ensure data security, SCSN is helping businesses accelerate their digital transformation and prepare for the future.

Conclusion Literature Study

The integration of digital tools like Azumuta, MKG and SCSN significantly enhances manufacturing and supply chain efficiency, quality control and collaboration. However, successful implementation requires a strategic understanding of each system's capabilities and limitations. As digital transformation progresses, businesses must stay adaptable to maintain a competitive edge.

3.1.4 Joker: IST – Process

Figure 2 shows the current situation in the assembly process of the 3D-printed bicycle. The process is based on the available manual and the information gathered by DataBridge during meetings and interviews with SuppyDrive.

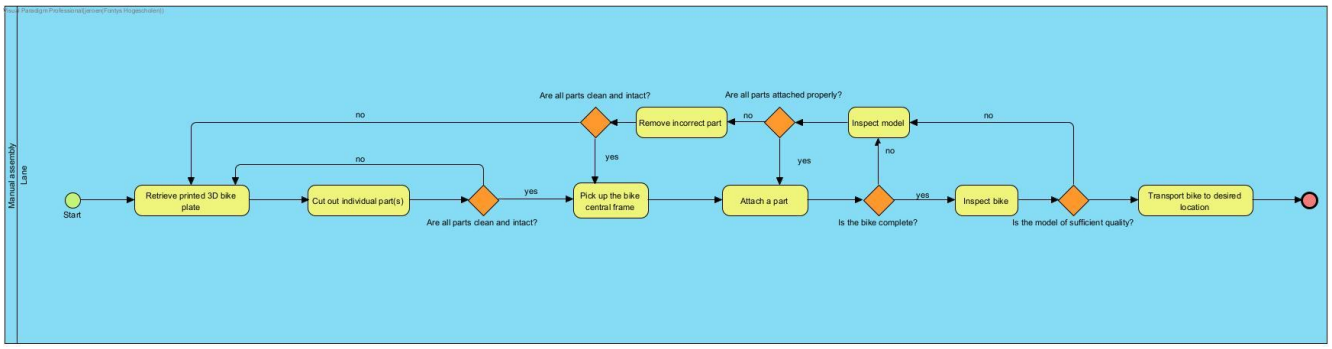


Figure 2: IST – Process

Conclusion IST – Process

As shown in figure 2, there are several loops within the process. Each time a part is attached, a loop is triggered and repeated until all components are assembled. In addition, several checks are performed to ensure that the bicycle is intact and correctly made.

Conclusion 1st Research Question

The current state of dynamic work instructions at Supplydrive is practically non-existent. While the ERP system MKG is connected to Azumuta, no instruction templates are available. Additionally, data cannot yet be sent back from Azumuta to MKG. In short, the connection exists, but the implementation of work instructions still needs to be developed.

3.2 What is the desired situation of dynamic work instructions at Supplydrive?

In this section of the document, one can find a brainstorming session that led to the creation of a mind map, the SOLL process, the requirements along with their prioritization using the MoSCoW method, the GAP-analysis and an analysis of available products.

3.2.1 Brainstorm session

A brainstorm session was conducted to get a clear view of the ideal situation for Supplydrive. During this session DataBridge made a mind map to visualize the situation. Figure 3 shows this mind map.

This brainstorm session is done to get aligned on what the desired situation for Supplydrive should yield.

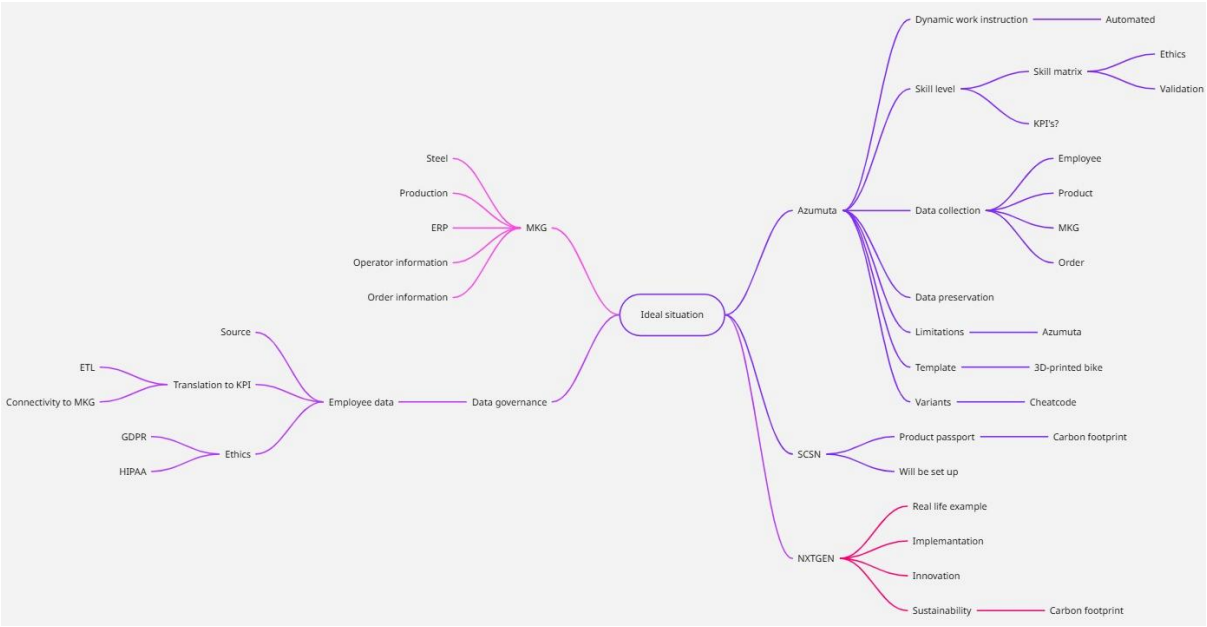


Figure 3: Mind map 2nd brainstorm

Conclusion Brainstorm

As illustrated in Figure 3, most of the ideal scenario unfolds within Azumuta. In this instructional work platform, DataBridge will develop the instructions for the case. However, DataBridge must not overlook the aspect of governance, which remains equally important.

3.2.2 Explore user requirements and requirement prioritization

Based on the information DataBridge gathered from discussions and interviews with Supplydrive, a set of requirements has been defined. In addition, priorities have been assigned to each requirement using the MoSCoW method. According to Brush (2023), the MoSCoW method is a technique used to categorize requirements into four levels of priority.

The first category includes the must-haves. Those are essential elements for completing the project. Next are the should haves, which are important but not critical. The could haves are desirable features addressed only if time and resources allow. Lastly, would haves are excluded from the current scope but may be considered in future developments.

Figure 4 shows the requirements for this project.

	Requirements Supplydrive	Priorities	Type
2	As a production manager, I want a dynamic work instruction system integrated with Azumuta, MKG and SCSN, so that work instructions are tailored to each employee's skill level and updated in real-time.	Must have	Functional
3	As an employee, I want work instructions tailored to my skill level, so that I can perform my tasks more efficiently and accurately.	Must have	Functional
4	As an admin, I want to maintain a skill matrix, so that I can track and manage the skill levels of all employees effectively.	Must have	Functional
5	As a manager, I want to define and comply with ethical and legal guidelines to ensure employees understand and adhere to company ethics and legal policies.	Must have	Functional
6	As a project manager, I want to be able to fill in a template for my specific assembly line to have dynamic work instructions for the operators based on their skill level.	Must have	Functional
7	As a product engineer, I want to develop a 3D-bike assembly line prototype in Azumuta, so that we can test and refine our assembly processes.	Must have	Functional
8	As a project manager, I want to capture employee data, including their skills and proficiency levels, and utilize it to match employees' working instructions to their skill level.	Must have	Functional
9	As Supplydrive, I want to integrate Azumuta with our existing systems, so that we can streamline our work instruction processes.	Should have	Technical
10	As Supplydrive, I want to integrate MKG with our existing systems, so that we can enhance our manufacturing processes.	Should have	Technical
11	As Supplydrive, we want to include compatibility with various ERP systems to ensure adaptability for diverse clients.	Should have	Non-Functional
12	As a project manager, I want a detailed implementation plan, so that Supplydrive can successfully integrate the dynamic work instruction system into their portfolio.	Should have	Non-Functional
13	As a business consultant, I want to provide advice on system integration, so that the company can achieve a smooth transition and maximize benefits.	Should have	Non-Functional
14	As a production planner, I want new orders to be received into the ERP system (MKG) and automatically forwarded to Azumuta, so that work instructions can be generated based on the latest production needs.	Should have	Functional
15	As an operator, I want to be able to switch to a lower instruction level manually, so that I can receive more instructions if needed for a certain task.	Should have	Functional
16	As a data custodian, I want to understand how GDPR (AVG) guidelines affect our ability to source employee data so we can ensure compliance.	Should have	Functional
17	As an operations manager, I want to define clear criteria for beginner, intermediate, and expert skill levels, so that operators can be evaluated and classified in a consistent way.	Could have	Functional
18	As an operations manager, I want to be able to view an intuitive interface to monitor task performance and workflow efficiency.	Could have	Functional
19	As an operator, I would like a feature to visualize skill improvement over time, offering tailored training suggestions.	Could have	Functional
20	As Supplydrive, I want to integrate SCSN with Azumuta and MKG, so that we can improve our supply chain communication.	Would have	Technical
21	As an operator, I want to be able to give feedback on a specific instruction step, so it becomes clear if an instruction is good or bad.	Would have	Functional
22	As an operations manager, I want new orders in Azumuta to be automatically assigned to an operator based on the required skill level, so that operators only receive tasks that match their capabilities.	Would have	Functional
23	As an operator, I want to incorporate multilingual capabilities in task instructions to cater to a diverse workforce.	Would have	Functional

Figure 4: Requirements & Prioritization

Conclusion Requirements

As shown in figure 4, the focus of this project lies in the creation of dynamic work instructions, the development of a skill matrix and the integration with the existing systems. The other requirements help to achieve this objective. The creation of the bicycle instructions and the template serve as examples of how this process can be used.

3.2.3 SOLL-process

The SOLL process is made to show what the desired situation for Supplydrive would be regarding the usage of tailored to operator skill level digital work instructions. This has been made for the bike but could be used as the base for a template.

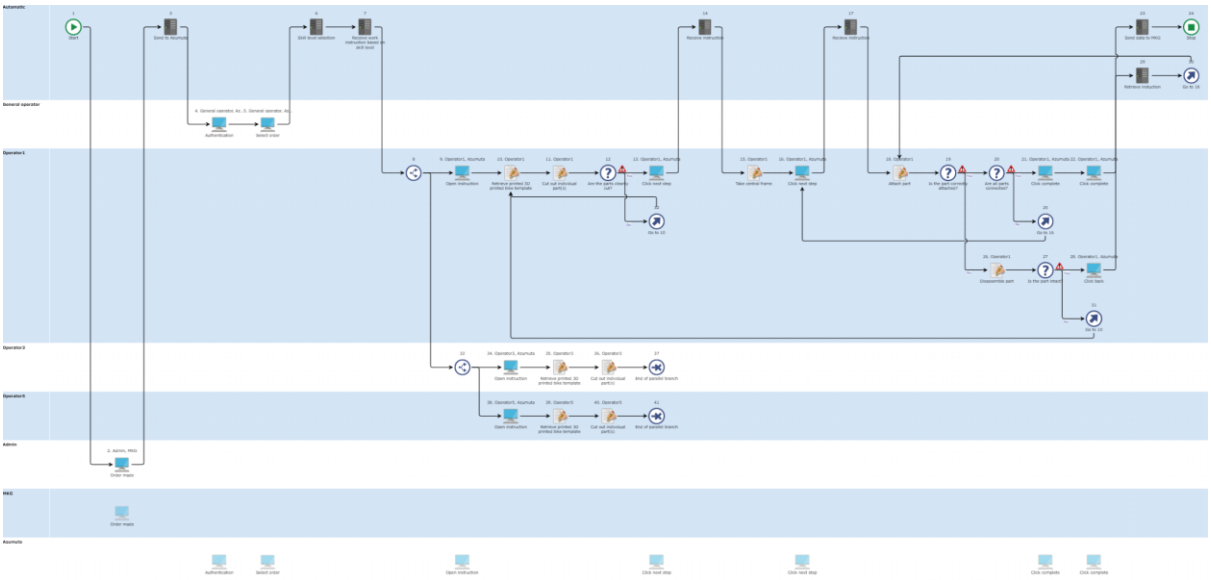


Figure 5: SOLL process

In figure five one can see how the desired situation is made. This describes the achievable desired situation. The main differences are the additions of a digital work instruction platform (Azumuta). This will digitalize the work instructions, capture operator data and ultimately match this according to a defined skill matrix. Each level of operator (beginner, intermediate and expert) will have a different set of instructions. The important part here would be how these are set up. It is important no steps are left out, creating an incomplete story.

3.2.4 GAP analysis

Based on the requirements identified during the research, eight key objectives have been formulated to bridge the gap between the current situation and the desired future state. These objectives include interconnected workstations, personalized work instructions, skill matrix development, virtual assembly modelling, operator data management, KPI tracking, skill improvement tools, and compliance with data legislation.

This GAP analysis reveals that the current operational environment lacks the digital integration, data-driven decision-making, and personnel development structures required to meet the future goals. Achieving the desired state will therefore require both technical upgrades such as implementing digital tools and platforms and process-oriented improvements, including clearer role definitions and data management protocols. Overall, the analysis emphasizes that a coordinated transformation across systems, skills, and workflows is essential to support the organization's strategic direction.

Supplydrive **Gap Analysis**

Analysis Date: 4/4/2025

No.	Strategic Objective / Requirement	Current State	Deficiency / Gap	Desired State
1	Interconnected workinstructions platform using Azumuta and connecting it to MKG and SCSN	Azumuta is live with a one way connection with MKG to send workinstruction orders to Azumuta	Data flows from MKG to Azumuta, but no return path or full integration with SCSN	Bi-directional integration between Azumuta, MKG, and SCSN could include product passport
2	Work instructions ordes tailored to employee skill level	Operators rely on static instructions	Current instructions are generic and do not adapt to individual skill levels	Dynamic instructions that adapt based on operator's skill level, pulled from skill matrix
3	Skill Matrix definition	Static instructions visible to all operators without regarding skill levels	No skill baselines defined; matrix not yet implemented	Centralized, up-to-date skill matrix that governs task assignments
4	Create a virtual assembly model (bycicle)	Operators use static instruction without software adaptation to assemble the product	No digital version of the assembly model currently exists	Virtual model that supports efficiency and optimization of production steps and instructions
5	Capturing operator data e.g. skill level, time spend	Operator data is stored seperatly in MKG and Azumuta without centralization	Operator data is not centralized or actively used	Centralized data storage of operator data used to personalize and optimize workflows
6	KPI Interfacing for middle management	Stored data is not being used to track operator KPI's	No central dashboard for performance or KPI tracking	Interactive dashboard showing real-time performance
7	Features to visualize skill improvement	No features are currently implemented to visualize this	No tracking or tailored development suggestions for operators	Visual tools to monitor individual growth and offer targeted training / Guidance
8	Compliance with data compliance laws	No current data security implementations are mentioned	Employee data is very sensitive	implement the correct protocols to ensure compliance with gdpr

Figure 6: GAP Analysis

3.2.5 Available product analysis

An available product analysis is a process that involves gathering, defining and analyzing data about a product or service to make informed decisions. This analysis aims to understand various aspects of the product, including its design, manufacturing process, costs, utility and market performance. By examining these factors, product managers and owners can identify strengths, weaknesses, opportunities and threats, which helps in optimizing the product for better market fit and user satisfaction (Saifi, 2022).

Table 5: Available product analysis digital work instruction platforms

	Requirements Supplydrive	Priorities	Azumuta	Visual Factory	3d Value	Manual.to	Ansomat	Arkite
2	As an employee, I want work instructions tailored to my skill level, so that I can perform my tasks more efficiently and accurately.	Must have	Yes	Yes	Yes	Yes	Yes	Yes
3	As an admin, I want to maintain a skill matrix, so that I can track and manage the skill levels of all employees effectively.	Must have	Yes	Yes	No	No	No	No
4	As a project manager, I want to be able to fill in a template for my specific assembly line to have dynamic work instruction for the operators based on their skill level.	Must have	Yes	Yes	Yes	No	Yes	Yes
5	As a product engineer, I want to develop a 3D-bike assembly line prototype in a digital work instruction platform, so that we can test and refine our assembly processes.	Must have	Yes	Yes	Yes	Yes	Yes	Yes
6	As a project manager, I want to capture employee data, including their skills and proficiency levels and utilize it to match employees working instructions to their skill level.	Must have	Yes	Yes	Yes	No	Yes	Yes
7	As Supplydrive, I want to integrate a digital work instruction platform with our existing systems, so that we can streamline our work instruction processes.	Should have	Yes	Yes	No	Yes	No	No
8	As Supplydrive, I want to integrate MKG with our existing systems, so that we can enhance our manufacturing processes.	Should have	Yes	No	No	Yes	No	No
9	As operator, I want to be able to switch to a lower instruction level manually, so that I can receive more instructions if needed for a certain task.	Should Have	No	No	No	No	No	No
10	As a operations manager, I want to define clear criteria for beginner, intermediate, and expert skill levels, so that operators can be evaluated and classified in a consistant way.	Could Have	No	No	No	No	No	No
11	As Supplydrive, I want to integrate SCSN with a digital work instruction platform and ERP, so that we can improve our supply chain communication.	Would have	Yes	Yes	No	Yes	No	No
12	As a operator, I want to be able to give feedback on a specific instruction step, so it becomes clear if an instruction is good or bad.	Would Have	No	Yes	No	No	No	No
13	As a operations manager, I want new orders in a digital work instruction platform to be automatically assigned to an operator based on the required skill level, so that operators only receive tasks that match their capabilities.	Would Have	No	No	No	No	No	No

What became clear from table 3 was that Azumuta is the most fitting solution looking at the requirements. Based on the demo's done by the company, other digital work instruction platforms focus on different things. Manual.to aims for quick and seamless implementation, with the vision that if it takes to long, the tool might already be redundant due to developments in the IT world. Azumuta is an all-round solution, not focussing on a specific part.

For this project, having some way to manage skills was needed. All but Azumuta and Visual Factory do not fit those criteria, although being great platforms. Thus, can be concluded that those could be used for the project as all must haves are available within that tool.

Also, a product analysis was conducted for the ERP systems.

Table 6: Available product analysis ERP systems

Requirements Supplydrive	Priorities	MKG	Ridder IQ	SAP	AFAS	Microsoft Dynamics
As a production manager, I want a dynamic work instruction system integrated with Azumuta, MKG and SCSN, so that work instructions are tailored to each employee's skill level and updated in real-time.	Must have	Yes	Yes	Yes	Yes	Yes
As Supplydrive, I want to integrate a digital work instruction platform with our existing systems, so that we can streamline our work instruction processes.	Should have	Yes	Yes	Yes	Yes	Yes
As Supplydrive, I want to integrate MKG with our existing systems, so that we can enhance our manufacturing processes.	Should have	Yes	Yes	Yes	Yes	Yes
As a production planner, I want new orders to be received into the ERP system and automatically forwarded to a digital work instructions platfrom, so that work instructions can be generated based on the latest production needs and assigned to the right employees.	Should have	Yes	Yes	Yes	Yes	Yes
As Supplydrive, I want to integrate SCSN with a digital work instruction platform and ERP, so that we can improve our supply chain communication.	Would have	Yes	Yes	Yes	Yes	Yes

A short conclusion can be drawn from this as all ERP systems could technically be used for the solution. Due to Supplydrive having close connections with MKG, that would be the preferred choice.

3.2.6 Conclusion

The ideal situation for dynamic work instructions at Supplydrive involves a seamless integration between MKG and Azumuta, enabling data exchange in both directions. Within Azumuta, work instruction templates are organized into three different levels, allowing each operator to engage with instructions that align with their individual skill set. Furthermore, a skill matrix is connected to these operator levels. Providing clear insight into when an individual is ready to progress to a higher level.

3.3 How can operator skill levels be defined, measured and assigned?

This section of the document outlines the efforts undertaken to address the third research question about the operator skill level. It includes an overview of good and bad practices, a prototype, a corresponding test case and a pitch.

3.3.1 Good and bad practices

Classifying work instructions based on operator skill level is essential for ensuring that tasks are assigned appropriately, enhancing efficiency and maintaining safety. This part examines the legal and ethical guidelines for this classification process, highlighting good and bad practices. For both topics a table is made that outlies the good and bad practices within the assembly line and factory occupation.

Legal and ethical guidelines

Since capturing employee data is quite a sensitive topic, it is important to adhere to legal guidelines when it comes to the storage and capture of it. Not only that, but there are also other legal restrictions when it comes to classifying operators. Table 5 shows an overview of general good and practices when it comes to adhering to legal and ethical guidelines.

Table 7: General good and bad practices

Good	Bad
Organizations should follow established classification standards such as the European Skills, Competences, Qualifications and Occupations (ESCO) system and guidelines from the International Standard Classification of Occupations (ISCO). These standards ensure consistency and fairness in job classification.	Avoiding arbitrary or inconsistent classification of work instructions is crucial. Such practices can lead to legal challenges and undermine the credibility of the classification system
Classifications must not discriminate based on race, gender, age, disability, or religion. Compliance with laws such as the Employment Equality Directive (EED) is essential to avoid legal repercussions.	Failing to adhere to established classification standards or other related legal guidelines could result in non-compliance with set rules, thus resulting in repercussions.
Ensure compliance with GDPR requirements for the collection and storage of employee data.	Keeping the classification criteria and process vague may result in dissatisfaction among employees. The determinant factors should be clear.
The classification process should be fair and logical. All (new) employees should have equal opportunity to be classified based on their skills and experience.	Ignoring feedback from employees that either passed or failed could result in more inaccurate classification.

(*European Skills, Competences, Qualifications and Occupations ESCO Handbook ESCO Handbook European Skills, Competences, Qualifications and Occupations*, 2017).

(European Commission, 2023)

Do's & Don'ts

Table 6 and 7 outline the do's and don'ts for assigning, defining, and measuring skill levels. These provide general guidance on what to do and what to avoid, when implementing and distributing skill levels within an organization (How to Measure Knowledge Skills and Abilities Effectively, 2024).

Table 8: Skill level do's

Do's	Explanation
Objective criteria for assigning skill levels	Do not rely only on the opinions of team leaders. Include measurable data such as time registration, quality control results and performance metrics to ensure fair and accurate evaluations.
Regular reassessment of skill levels	Skills can improve or decline over time. Regular reassessments help ensure that skill levels reflect the current abilities of each employee.
Transparency to operators	Employees should know their current skill level, understand the reasons behind it and be aware of what they need to do to progress. This promotes fairness and motivation.
Structured list of skills	Clearly define which skills are needed for each skill level. This helps employees understand expectations and provides a clear path for development.
Role-based skill level	Different job roles require different skills. Make sure the criteria for assigning skill levels are tailored to the specific responsibilities of each role.
Standardized scheme	Use a consistent and clearly defined system to assess all employees. This ensures fairness and clarity. If the framework changes, communicate this clearly to all employees.
Use tests / certifications	Tests and certifications are useful tools to objectively verify whether an employee has mastered a specific skill. They complement practical experience and observation.
Use Skill Matrix	A skill matrix provides a visual overview of the skills and levels of all employees. It helps identify strengths, gaps and training needs across the team.
Use results as training	If certain skill gaps are identified, use that information to offer targeted training. This ensures that development efforts are aligned with actual needs.

Table 9: Skill Level don'ts

Don'ts	Explanations
Assign skill level on gut feeling	Making decisions based on intuition rather than data can lead to unfairness and inconsistency. It increases the risk of favouritism and undermines trust in the evaluation process.
Lack of feedback / Evaluation	Without regular feedback, employees may remain stuck at the same skill level. Constructive feedback is

	essential to help them understand how to improve and grow.
Self-assessment	Employees often misjudge their own abilities. They either overestimating or underestimating themselves. Self-assessment alone is not a reliable method for determining skill levels.
Ignoring soft skills	Focusing only on technical skills can give an incomplete picture. Soft skills such as communication, teamwork and adaptability are also critical for overall performance.
Too much trust in certifications	While certifications are helpful, they do not always reflect real-world expertise. Holding a certificate does not necessarily mean an employee has mastered the skill in practice.

Conclusion

To conclude, adhering to both ethical and legal guidelines is crucial when defining operator skill levels. By employing standardized methods that are applied equally to all operators, organizations can ensure that skill levels are determined in a fair and unbiased manner. This approach not only promotes compliance with regulations but also fosters a transparent and equitable work environment.

3.3.2 Prototype – Guide to defining skill levels

This part of document yields research done into how define the skill levels of operators with a guide to classification.

What is ESCO?

ESCO (European Skills, Competences, Qualifications and Occupations) is a multilingual system that classifies and organizes the skills, qualifications and job roles that are important across Europe its labour market and education systems.

It was created by the European Commission with several goals:

- To help education and training systems communicate more effectively with the labour market.
- To promote both job and geographic mobility within Europe.
- To make data about jobs and skills clearer and more accessible for stakeholders like employment services, educational institutions and statistical agencies.
- To make it easier for employers, educators and job seekers to exchange information across different languages and countries.
- To support policymaking by providing better tools for analysing real-time data on skills demand and supply using big data.

ESCO is organised through the usage of three pillars:

- The occupations pillar
- The knowledge, skills and competences pillar
- The qualifications pillar

These pillars are interlaced with each other as can be seen in the figure below.

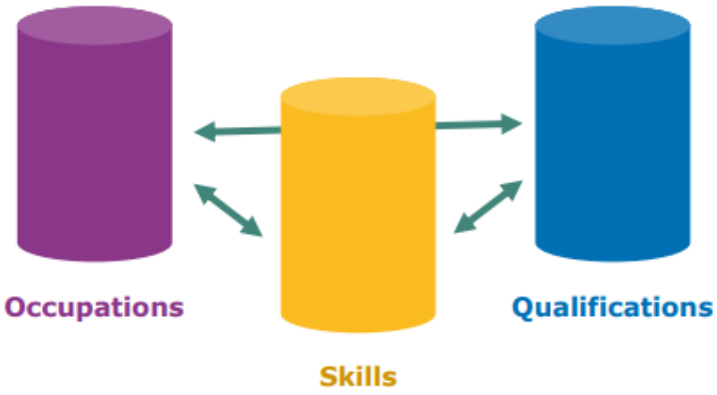


Figure 7: Correlation ESCO pillar structure

Employers can use ESCO to explore occupations and skills that are relevant to the labour market. However, it is also important to consider whether an occupation is subject to legal requirements. Therefore, any laws regulating access to certain professions must also be considered.

Each ESCO occupation there are essential and optional concepts regarding skills, knowledge and other competences. Essentials are the ones that are always relevant within the occupation.

Optional is there for specific employers, or different working contexts within the same occupation. As an example, a pilot should always be knowledgeable on how to contact the tower at the airport (essential) but might need optional knowledge when flying a different airplane (*European Skills, Competences, Qualifications and Occupations ESCO Handbook ESCO Handbook European Skills, Competences, Qualifications and Occupations*, 2017).

Differences between an occupation, a job or career

An occupation is a broader term that describes a category of work that involves similar tasks and requires a particular set of skills and training. It encompasses many different jobs that fall under the same professional field. For instance, the occupation "teacher" includes jobs such as a software developer or college lecturer. These roles may vary by workplace but are united by common functions and qualifications.

A job refers to a specific position held by an individual within a company or organization. It includes duties, responsibilities and tasks assigned to that role. A job often has a title and is usually performed for a certain wage or salary. It can be part-time, full-time, temporary, or permanent. Examples include a front-end developer at a startup or calculus professor at the Technical University of Eindhoven (TU/e).

A career would be to enveloping term of the three. It shows the journey taken by an individual, possibly including multiple jobs within one or more occupations (*Career Services*, n.d.).

The concepts of knowledge, skills and competence

To define these concepts of knowledge, skills and competence the table below structures eight levels of these concepts. It outlines basic requirements needed that are specified per occupation or job.

Table 10: Levels of knowledge, skills and competence (Description of the Eight EQF Levels | Europass (n.d.))

EQF Level	Knowledge	Skills	Competence
Level 1	Knows simple, basic facts	Can do basic tasks with simple tools	Needs close supervision and works in a clearly structured setting
Level 2	Understands key facts in a specific area	Can solve routine problems with simple methods	Can work with some independence but still under guidance
Level 3	Knows main ideas and how things generally work in a field	Can choose and use basic tools to complete tasks and solve everyday problems	Takes responsibility for finishing tasks and adjusts to changes
Level 4	Has solid knowledge and some theory in a broad area	Can solve specific problems using a variety of methods	Manages own work and may supervise others in mostly predictable situations
Level 5	Has detailed knowledge and understands where the limits are	Can think creatively and solve unusual problems	Manages change and helps others improve, taking initiative when needed

Level 6	Understands complex ideas and principles in depth	Can apply advanced methods to deal with difficult or changing situations	Leads projects, makes key decisions, and helps others grow professionally
Level 7	Has deep, expert knowledge, often used for research or new ideas	Can solve new, complex problems and combine knowledge from different areas	Thinks strategically, leads in uncertain situations, and advances the profession
Level 8	Understands the newest and most complex knowledge in their field	Creates new knowledge or practices through innovation and research	Leads with authority, develops original ideas, and drives change at the highest level

Define the job – step one

Based on the research above, it is possible to define, measure and assign skill levels within a company. To achieve this, a company should follow several steps. The first step is to clearly define the job that needs to be done and identify the specific skills required for it.

This can be done by following the three pillars established by ESCO. When describing a job, clear criteria can be defined for each pillar to determine what is truly necessary for someone to be eligible to work in that role. Once somebody meets all these criteria, the person can be hired and be assessed on what skill level they have.

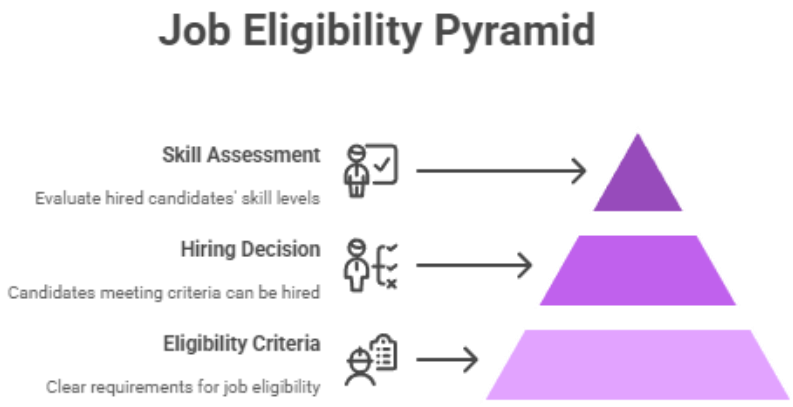


Figure 8: Job eligibility pyramid (napkin.ai)

Define skill level – step two

Before an operator is hired, the person must meet certain minimum requirements. To determine the skill level of an individual, clear criteria must first be established. As outlined in the 'Good and bad practices', there are various matrices and guidelines that indicate what should or should not be followed. Table 6, mentioned earlier, can also support this process.

A company can utilize a set of Key Performance Indicators (KPI's) to evaluate employee performance. These KPI's can vary depending on the specific context and type of assembly involved. Each organization determines its own relevant indicators. Examples of such KPI's include flight hours, the number of times a product has been assembled, average production

speed and error rate. As well as the completion and periodic renewal of specific training courses.

Ultimately, there should be a structured list used to evaluate employees. Based on that list, a matrix can be created to see where an employee stands within each sub-area of a skill.

Measure skill level employee – step three

Now that the skill levels have been defined in the previous step, each employee can be evaluated against this list to measure the individual skill level. This assessment must be conducted fairly, as outlined in the 'Do's & Don'ts'. In this way, every employee is assigned a skill level, giving the employer a clear overview of where each employee stands.

Assign skill level employee – step four

Based on the third step, each employee is now assigned to a specific skill level. The employer can use this information to adjust tasks and responsibilities, ensuring that employees are doing work that aligns with their strengths, as indicated by their skill level. This helps the company operate more efficiently by leveraging the capabilities of its workforce. Additionally, the employer can identify areas where an employee excels or struggles. This insight can be used to provide targeted training, helping to close any skill gaps. Over time, this approach not only improves individual performance but also strengthens the overall skill base of the organization.

Repeat the steps – step five

An employee can grow within their role and enhance their skills over time. However, it is also possible for certain skills to decline if they are not regularly practiced or updated. That is why ongoing reassessment is essential. Figure 8 clearly illustrates this cycle. It is important to revisit this process periodically to determine whether anything has changed – such as improvements resulting from training or certifications. Regularly repeating this cycle ensures that both the employee's development and the company's expectations remain aligned.

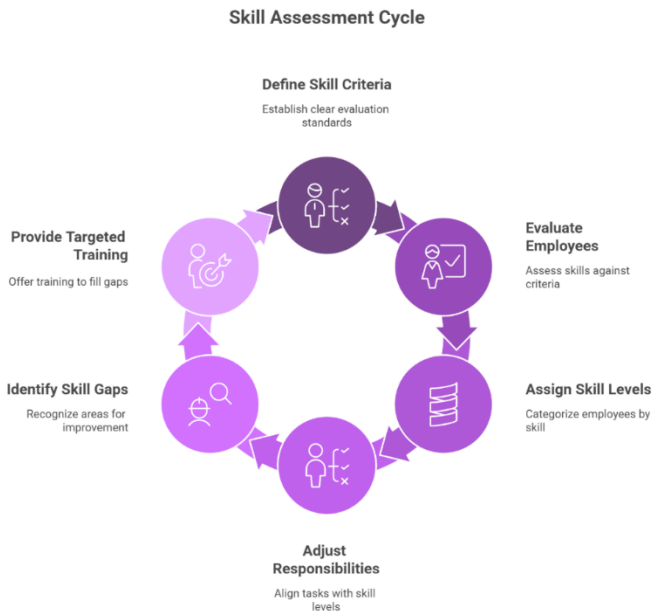


Figure 9: Skill assesment cycle

3.3.3 Pitch

To present the results of the third sub-question to Supplydrive and TNO stakeholders, a pitch was delivered. During a meeting with the participating companies, a presentation was used to share and discuss the progress made in the research on defining skill levels and the associated best and worst practices.

The figure below shows one of the slides used in the pitch, which explained what is required and permitted under GDPR regulations regarding employee skill levels.

Figure 10: Slide pitch

The stakeholders responded positively to the outcomes presented. The content reflected the findings from previous chapters, including the research insights and practical do's and don'ts.

3.3.4 Conclusion

In conclusion, operator skill levels can be defined using standardized framework such as the European Qualification Framework (EQF) and the European Skills, Competences, Qualifications and Occupations (ESCO) handbook, which provide structured criteria across knowledge, skills and competences. Measurement should be based on objective, transparent metrics, including experience, training, task performance and certifications. Assignment should follow a clear, replicable process that respects data privacy (e.g. GDPR compliance) and avoids bias. Good practice involves standardized assessments, while bad practice includes using vague or subjective criteria.

3.4 How can a template system for product instructions be developed to accommodate varying skill levels and be applied to the assembly of a miniature bike?

This section of the document outlines the efforts undertaken to address the fourth research question about how to make digital work instructions for a miniature bike. It includes multiple iterations of a prototype, usability testing and a product review.

3.4.1 Prototype

The goal of the prototype is to demonstrate how dynamic work instructions can be adapted to the skill level of the employee assembling a product, in this case a plastic bike made of 3D-printed parts. To achieve this, DataBridge created three versions of work instructions, each tailored to a different skill level:

Beginner: Includes detailed steps such as cutting and cleaning parts before assembly (figure 11)

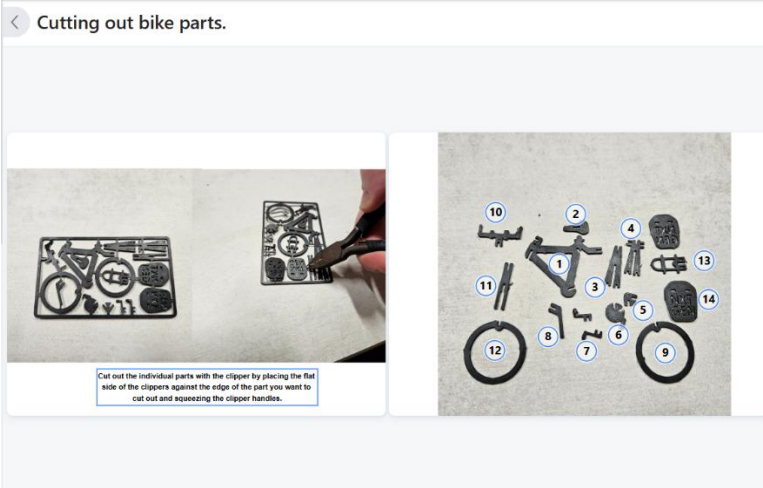


Figure 11: Beginner detailed instruction

Intermediate: Focuses on standard assembly procedures with moderate guidance (figure 12).

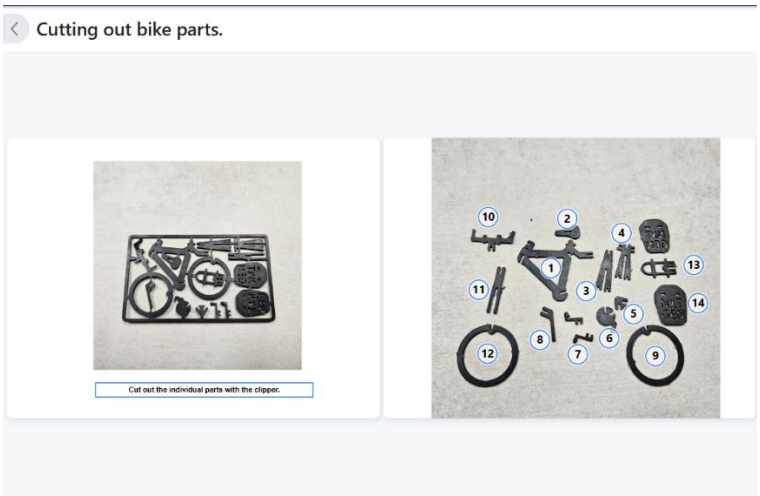


Figure 12: Intermediate detailed instruction

Expert: Condenses instructions, assuming prior knowledge and high skill, streamlining the process into fewer, more efficient steps

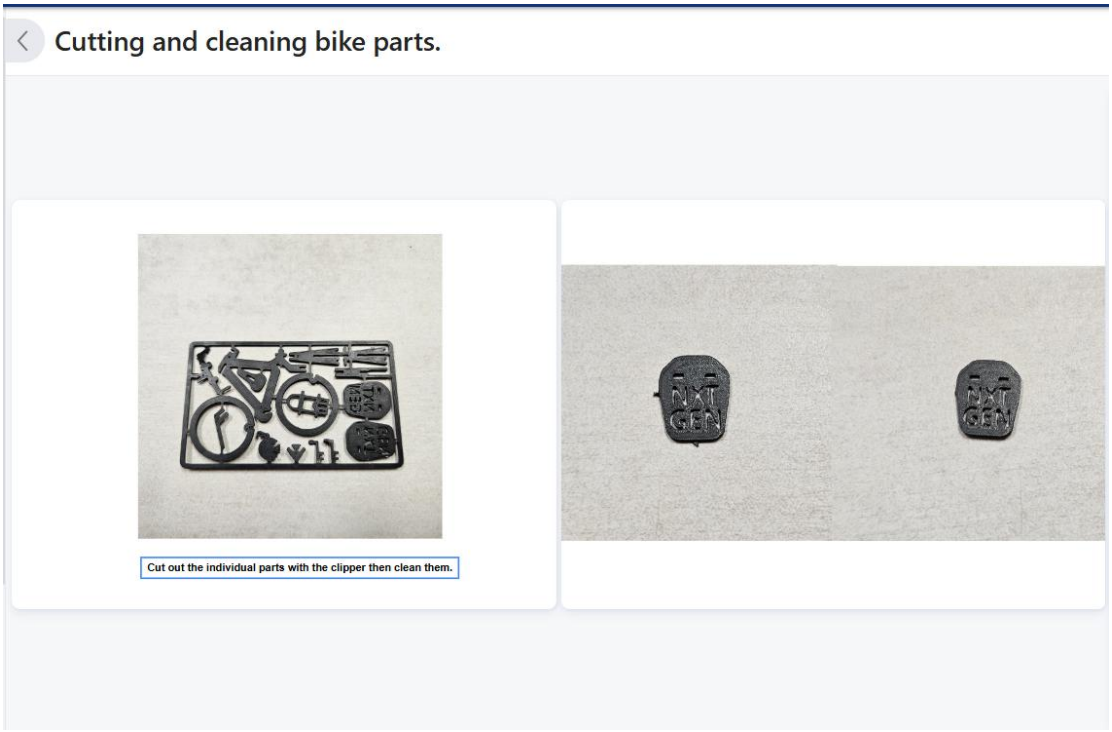


Figure 13: Expert instructions cleaning and cutting

These screenshots highlight how platforms like Azumuta can dynamically adjust instructions to match user proficiency, improving productivity and minimizing errors.

What is an MVP and why it is used

This prototype functions as an MVP, a minimal viable product. This is the simplest version of a product that still delivers core value to users. It allows teams to quickly test assumptions, collect feedback and iterate without overinvesting in features that may not be needed.

The MVP approach was chosen based on **lean methodology** principles:

- **Speed**: Developing only what was essential saved time and allowed us to deliver a functional prototype early.
- **Validation**: By presenting basic functionality (three instruction levels), we could test our core concept and gather feedback.
- **Efficiency**: We avoided wasting resources on features that might not be useful or feasible in the final product (MVP E. Ries).

3.4.2 Usability Test 1

To test the effectiveness and usability of the prototype, user tests were conducted during a Fontys event where both students and teachers had the opportunity to interact with the system. At the stand, participants were invited to assemble a plastic bike using the beginner working instructions provided by the prototype. This hands-on session was designed to simulate a real-world assembly scenario and give insight into how well the instructions supported users with varying levels of experience.

In total, eight volunteers participated in the test. Of these, four were able to complete the bike assembly within the time they had. The fastest completion time was around fifteen minutes, while the slowest participant finished in approximately twenty minutes. These results demonstrated that the instructions were functional and relatively efficient but also highlighted areas where further refinement could improve user experience.

One of the most valuable pieces of feedback received during the event was the suggestion to take inspiration from how Lego presents its building instructions. Participants noted that Lego manuals always begin each section by showing the result of the upcoming steps, providing a clear visual reference of what they are working toward, before breaking down how to achieve that outcome. This method was considered highly effective for keeping users oriented and motivated, and it was suggested that a similar approach could make our instructions more intuitive and easier to follow.

Another recurring theme in the feedback was the need for clearer visuals. While the current images provided a basic understanding of each step, many users expressed that they would benefit from richer visual aids, such as short videos or animations, to help clarify the more complex parts of the process. This is particularly relevant for beginner users who might struggle with spatial orientation or interpreting static diagrams.

3.4.3 Usability Test 2

These test results describe the test conducted of the prototype that is used for the guide.

Summary of results

The second prototype of the dynamic work instruction system was tested with two participants, one beginner and one expert, using the Azumuta interface and a physical prototype. The goal was to evaluate usability, clarity, adaptability to skill levels and functional accuracy of instructions integrating visual aids and QA checkpoints.

Task performance summary

Table 11: Task performance summary

Metric	Beginner Participant	Beginner Participant
Total Time to Complete Task	24:08 minutes	12:26 minutes
Number of Clarification Requests	3	1
Number of Errors	2	8+
Use of Support Features	All videos used	Videos mostly ignored
QA Checkpoints Followed	Yes	Not consistently
Confidence During Execution	Reasonably confident	Low initially; confident later without instructions
Notable Observations	Relied on videos; some confusion around cleaning steps	Skipped steps; relied on overview images; showed impatience

Behavioural observations

- Beginners benefited significantly from videos and followed the step-by-step instructions.
- BOM and cleaning steps caused uncertainty for both users.

Post-test survey highlights

- Instructions Clarity (avg): 3.5 / 5
- Visuals Usefulness (avg): 4.5 / 5
- Confidence During Assembly (avg): 5 / 5
- Tool/Part Awareness (avg): 4 / 5

Identified improvement areas

- Emphasize that explanations follow images to avoid premature assembly.
- Consider mandatory prompts or visual cues for critical QA steps.
- Introduce clearer labelling of parts and blueprint-style overviews.
- Improve tool clarity, especially regarding BOM and cleaning procedures.
- Consider user-specific interaction paths (e.g., bypass options for experts with warnings).

Conclusion

The dynamic work instruction system shows promising usability, particularly for beginners. Visual aids are effective, but their impact is limited if ignored. Expert users require a tailored experience to prevent errors due to overconfidence or impatience. Overall, the prototype is

functional but would benefit from refinements in user guidance and clarity, especially in supporting expert workflows.

3.4.4 Usability Test 3

These test results describe the test conducted of the prototype that is used for the guide.

Summary of results

The second prototype of the dynamic work instruction system was tested with two participants, both beginners, using the Azumuta interface and a physical prototype. The goal was to evaluate usability, clarity, adaptability to skill levels and functional accuracy of instructions integrating visual aids and QA checkpoints.

Task performance summary

Table 12: Task performance summary

Metric	Beginner Participant	Beginner Participant
Total Time to Complete Task	24:13 minutes	18:40 minutes
Number of Clarification Requests	Not recorded	2
Number of Errors	Not recorded	2
Use of Support Features	All videos used	All videos and images used
QA Checkpoints Followed	Yes	Not consistently
Confidence During Execution	Low at first; increased over time	Moderate; sometimes unsure
Notable Observations	Skipped steps, hesitant at start, confident at end	Missed steps, frequent backtracking, broke part due to confusion

Behavioural observations

- Both beginners relied heavily on visual content; however, some steps remained unclear.
- The lack of clarity around certain parts and tools led to repeated steps and minor assembly mistakes.
- Attention span issues and interface confusion contributed to incorrect task completion.
- One participant broke a part (handlebars) by applying too much force.
- Cleaning instructions and naming of parts were reported as unclear or missing context.
- Visual misalignment (e.g., bike stand image) led to misunderstanding of the current assembly state.

Post-test survey highlights

- Instructions Clarity (avg): 4 / 5
- Visuals Usefulness (avg): 4.5 / 5
- Confidence During Assembly (avg): 5 / 5

- Tool/Part Awareness (avg): 3.5 / 5

Identified improvement areas

- Clarify instructions around ambiguous parts such as the back frame and cleaning process.
- Improve visual alignment between current product state and instruction imagery (e.g., bike carrier presence).
- Ensure naming of parts is consistent and visible throughout (label or code matching).
- Refine instructions to prevent critical mistakes such as assembly of incomplete components.
- Add more detailed descriptions around tool usage and critical steps.

Conclusion

The dynamic work instruction system demonstrates value for beginner users but shows room for improvement in clarity and error prevention. Visual content remains essential but should be supported with better part identification and clearer instruction flow. Ensuring the sequence of tasks is unambiguous and that QA steps are reinforced can greatly enhance user confidence and product accuracy.

3.4.5 Azumuta Demo

In addition to public testing, DataBridge also conducted a demo session with representatives from Azumuta. During this session, insightful feedback on how dynamic work instructions is typically implemented in practice was received. Azumuta noted that in most real-world cases, users usually create a single, comprehensive instruction set aimed at beginners. More experienced workers are then allowed to skip non-essential steps based on their own judgment or system settings. This essentially results in a two-tier instruction system: one full version for novices and a shortened path for experts. The previous prototype tried to work with 3 skill levels but during the demo the representative of Azumuta said that this was not possible within Azumuta if all the functionalities are used as intended.

combination of hands-on testing and expert feedback has been instrumental in identifying both strengths and areas for growth in our MVP. It confirms the core value of dynamic work instructions while offering clear direction for future iterations.

3.4.6 Prototype v2

The second version of the prototype introduces several functional and structural enhancements compared to the initial version. These changes focus on improving user adaptability, instructional clarity and visual guidance within the assembly process of the plastic bike.

Dynamic instructional design

A major conceptual shift in the second version is the implementation of dynamic working instructions based on user proficiency levels. Instead of developing separate instruction sets, a single base instruction structure is used for both beginner and expert levels.

- Beginner users follow the full sequence of steps, ensuring comprehensive guidance through every phase of the assembly process.
- Expert users are presented only with the critical steps, which are identified by integrated quality assurance (QA) checks. These users still retain the option to access detailed instructions if necessary, promoting flexibility without compromising quality or completeness.

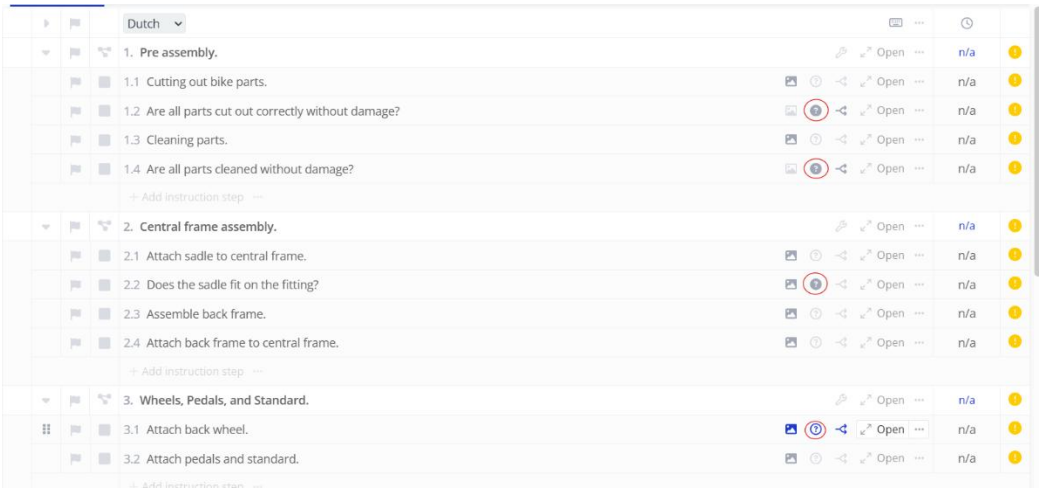


Figure 14: Indication critical steps

This approach increases instructional efficiency and scalability while supporting user autonomy and minimizing redundant information for experienced operators.

Enhanced visual orientation

The second version improves the visual structure of the instructions to increase understanding and reduce cognitive load:

Each chapter begins with a full-picture overview of the section's assembly goal, providing immediate visual context and orientation (figure 15).

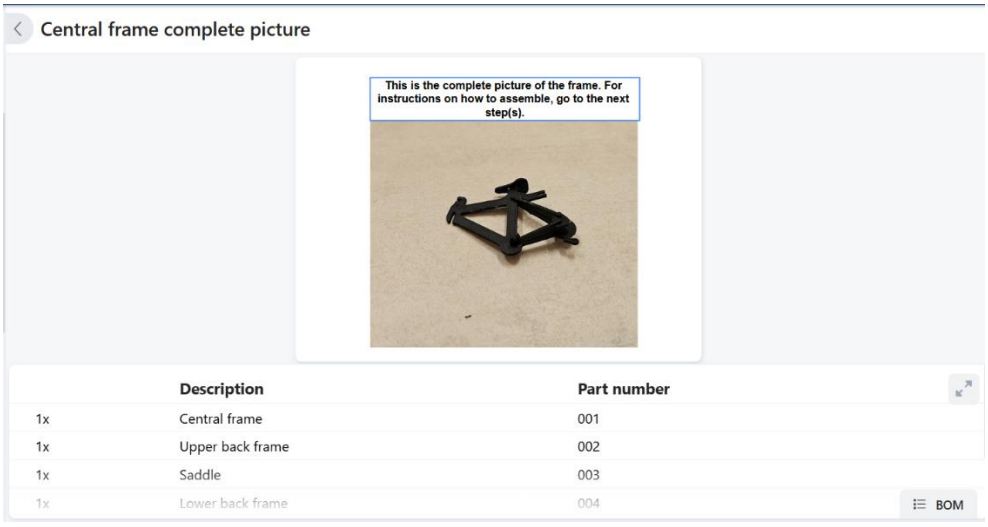


Figure 15: Example full-picture overview

Videos have been incorporated into nearly every step, offering dynamic, real-world demonstrations that clarify the expected results and techniques. This is a significant upgrade from Version 1, which relied solely on static images and text (figure 16).

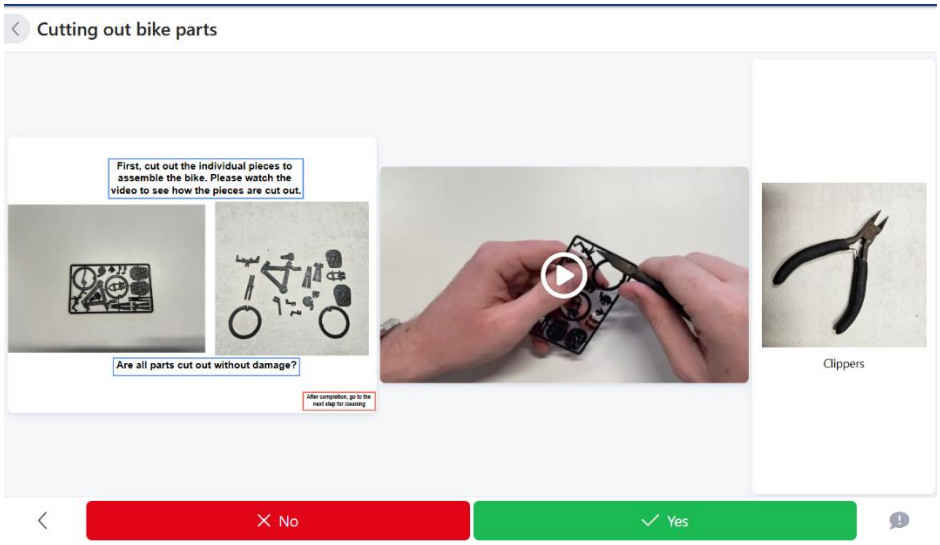


Figure 16: Example video

These changes support better comprehension and accessibility for users of varying skill levels and learning styles.

Tool and terminology updates

Version 2 standardizes terminology to match with the BOM, like central frame and lower central frame and replaces the knife used in version 1 with a file for cleaning parts, reflecting a refined approach to handling components more safely and effectively.

Differences between the versions of our prototype can be found in the accompanying PDF files of our prototype versions.

3.4.7 Product Review

DataBridge has reviewed both the first and second versions of the prototype with Supplydrive. Like the testing phase, several points emerged during this process. One notable adjustment involved the use of a file instead of a knife, implemented as a safety precaution. Additionally, videos were incorporated to provide enhanced visual support and a BOM was added for clarity.

An innovative suggestion from Supplydrive was to increase contrast within instructional steps. This was achieved by utilizing both a black and a white bicycle, allowing for clearer visibility of smaller components through contrasting visuals. Supplydrive expressed satisfaction with the final prototype and has decided to feature it at an upcoming exhibition as both a test case and a showcase.

3.4.8 Conclusion

In conclusion, Azumuta offers a foundation for creating dynamic, skill-based work instructions that adjust to the needs of individual operators. In the case of assembling a miniature bike, the platform demonstrates how layered instructions can be structured to support both beginner and experienced operators. This approach highlights the potential for scaling to more complex assembly processes.

At Supplydrive, the ideal implementation includes seamless integration between MKG and Azumuta, enabling efficient data exchange and centralized instruction management. Within Azumuta, it is possible to work with multiple instruction levels directly linked to a skill matrix, allowing operators to receive guidance tailored to their capabilities. This setup not only enhances instructional clarity and flexibility but also supports structured operator development and continuous improvement.

4 Main question

The main research question: "How can Supplydrive create dynamic work instructions, tailored to operator skill levels, to improve the quality of service provided to clients?"

In conclusion, Supplydrive can support clients in creating dynamic work instructions by providing both a comprehensive implementation guide and technical integration services. Through its core expertise in managing data flows, such as connecting ERP systems with Azumuta, the recommended platform for digital work instructions, Supplydrive can lay the foundation for dynamic work instructions within operational processes.

The guide outlines a high-level, step-by-step approach that organizations can follow to adopt digital work instructions effectively. It also provides practical guidance on how to differentiate instructions based on operator skill levels, enabling tailored workflows across the assembly process.

Azumuta enables a single work instruction to adapt to different operator skill levels by offering three distinct variants within the same process. This ensures that each operator receives guidance appropriate to their experience, which helps speed up production tasks. This not only enhances workforce adaptability but also results in improved improves productivity, reduces errors and supports continuous learning

By combining the DataBridge-developed guide with Supplydrive its system integration services, they can offer a complete and scalable solution to help assembly companies improve performance and quality through dynamic, skill-driven digital work instructions.

5 Sources

About Azumuta: Pioneering Digital Transformation in Manufacturing. (2025, February 19). Azumuta. https://www.azumuta.com/company/

admin. (2024, February 18). *ERP for Steel Industry: industry specific benefits and features - Rsult*. Rsult - Going for the Ultimate Rsult. https://rsult.one/erp-per-industry/erp-for-steel-industry-industry-specific-benefits-and-features/

ARTICLE29 - Item. (n.d.). Ec.europa.eu. https://ec.europa.eu/newsroom/article29/items/623051

Azumuta. (2023, November 13). *Top features of Azumuta Digital Work Instructions | Demo*. YouTube. https://www.youtube.com/watch?v=Er4wf-RPkOY

Career Services. (n.d.). https://www.elcamino.edu/support/careers/DifferenceJob_Occupation_Career.pdf

De voordelen van SCSN. (2025). Smart-Connected.nl. https://smart-connected.nl/nl/over-scsn-nieuw/voordelen-scsn

Definition of Architecture - Gartner Information Technology Glossary. (n.d.). Gartner. https://www.gartner.com/en/information-technology/glossary/architecture

Description of the eight EQF levels | Europass. (n.d.). Europass.europa.eu. https://europass.europa.eu/en/description-eight-eqf-levels

Digital Work Instructions: Everything You Need to Know - Azumuta. (2024, February 14). Azumuta. https://www.azumuta.com/blog/digital-work-instructions-full-guide/

Enkhuizen, L. van. (2024, April 28). *The 10 Best ERP Software for Metalworking and Metal Fabrication (2025)*. Sheet Metal Connect. https://www.sheetmetalconnect.com/the-10-best-erp-software-for-metalworking-and-metal-fabrication/

European Commission. (2023). *Legislation - Employment Equality Directive (2000/78/EC)*. Employment, Social Affairs and Inclusion. https://employment-social-

affairs.ec.europa.eu/policies-and-activities/rights-work/tackling-discrimination-work/legislation-employment-equality-directive-200078ec_en

European Skills, Competences, Qualifications and Occupations ESCO handbook ESCO handbook European Skills, Competences, Qualifications and Occupations. (2017). https://esco.ec.europa.eu/system/files/2021-07/Handbook.pdf

European Union. (2016, April 27). *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)*. Europa.eu. https://eur-lex.europa.eu/eli/reg/2016/679/oj

Hoe SCSN werkt. (2015). Smart-Connected.nl. https://smart-connected.nl/nl/over-scsn-nieuw/hoe-scsn-werkt

How to Measure Knowledge Skills and Abilities Effectively. (2024, September 13). Jadeer. https://jadeer.ai/how-to-measure-knowledge-skills-and-abilities/

How to Use Azumuta - Azumuta Knowledge Base. (2025). Azumuta. https://www.azumuta.com/docs/category/how-to-use-azumuta/

How to write work instructions. (n.d.). Gluu. https://gluu.biz/how-to-write-work-instructions/

How to Write Work Instructions That Are Easy to Follow. (n.d.). Www.getmaintainx.com. https://www.getmaintainx.com/blog/how-to-write-work-instructions

Howell, C. (2024, January 11). *Digital Work Instructions Explained: The Ultimate Guide*. LightGuide. https://www.lightguidesys.com/resource-center/blog/digital-work-instructions-explained-the-ultimate-guide/

IST Soll, een heldere uitleg en duidelijk voorbeeld. (2023, January 10). Optie24. https://optie24.nl/algemeen/ist-soll/

Jurevicius, O. (2023, October 26). *Gap Analysis: The Definitive Guide - SM Insight*. Strategic Management Insight. https://strategicmanagementinsight.com/tools/gap-analysis/

Knight, M. (2017, December 18). *What is Data Governance? - DATAVERSITY*. DATAVERSITY. https://www.dataversity.net/what-is-data-governance/

Kück, M. (2025). *Enterprise Architecture Management*. Gbtec.com; GBTEC. https://www.gbtec.com/resources/eam-enterprise-architecture-management/

ProductPlan. (2024). *What Is MoSCoW Prioritization? | Overview of the MoSCoW Method*. Productplan.com. https://www.productplan.com/glossary/moscow-prioritization/

Saifi, N. (2022, June 15). *Product Analysis: Types, Methods, and Examples*. Chisel. https://chisellabs.com/blog/product-analysis/

Simon, D., Fischbach, K., & Schoder, D. (2013). Enterprise architecture management and its role in corporate strategic management. *Information Systems and E-Business Management*, *12*(1), 5–42. https://doi.org/10.1007/s10257-013-0213-4

Smart Connected Supplier Network. (2025). Smart-Connected.nl. https://smart-connected.nl/nl/over-scsn-nieuw

The Open Group. (2019). *The ArchiMate® Enterprise Architecture Modeling Language | The Open Group*. Opengroup.org. https://www.opengroup.org/archimate-forum/archimate-overview

Tracxn. (2021, August 17). *MKG*. Tracxn.com; Tracxn. https://tracxn.com/d/companies/mkg/__m2V6mvK6hLtvyCU6IUU2DSsHAWvPogBtIKyjpWnFdbk

U.S. Office of Personnel Management. (2005). *The Classifier's Handbook*. https://www.opm.gov/policy-data-oversight/classification-qualifications/classifying-general-schedule-positions/classifierhandbook.pdf

Unlocking Manufacturing Excellence: Discover Why Azumuta Leads the Industry. (2025, February 19). Azumuta. https://www.azumuta.com/why/

van Turnhout, K. (n.d.). *ICT Research Methods — Methods Pack for Research in ICT*. ICT Research Methods. Retrieved April 3, 2025, from https://ictresearchmethods.nl/dot-framework/

Wat is data governance? | Definitie, belang, & Typen | SAP. (2025). SAP. https://www.sap.com/netherlands/products/data-cloud/master-data-governance/what-is-data-governance.html

Werkgroep Data Maturity | Stichting DAMA NL. (2025). Dama-Nl.org. https://dama-nl.org/werkgroepen/werkgroep-data-maturity/

Wolfartsberger, J., & Niedermayr, D. (2020). Authoring-by-Doing: Animating Work Instructions for Industrial Virtual Reality Learning Environments. *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. https://doi.org/10.1109/vrw50115.2020.00038