D9.3 Evaluation Report of the iPRODUCE Digital Platform

AIDIMME

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Abstract	D9.3 is the result of the evaluation of the Open Innovation Space (OpIS) tools of iPRODUCE, performed by the Collaborative Manufacturing Demonstration Facilities (cMDFs) with the participation of additional partners of the project, providing feedback in two different stages (mid-term and final round). This document reports the level of user satisfaction using the tools through the heuristics assessment, and the compliance with the requirements coming from the local cMDFs through the KPI validation. It should be emphasized the inclusion of an Annex at the end of the document that reports the latest improvements in the tools and its evaluation during the last period of the project.

DELIVERABLE HISTORY			
Date	**Version**	**Author/ Contributor/ Reviewer**	**Summary of main changes**
2021/04/08	0.1	AIDIMME	Initial version
2021/10/29	0.2	AIDIMME	Evaluation methodology
2022/05/02	0.3	AIDIMME	Additions in introduction
2022/05/03	0.4	AIDIMME	Overall changes in structure
2022/08/02	0.5	AIDIMME	Additions to heuristic and KPIs midterm
2023/03/21	0.6	AIDIMME, cMDFs users	Additions to KPIs final round
2023/03/22	0.7	AIDIMME	Evaluation methodology
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2023/03/27	0.9	AIDIMME	Additions to heuristic final round and conclusions
2023/03/31	1.0	AIDIMME, F6S	Final version after internal review
2023/06/05	2.3	AIDIMME, technical partners (tool´s developers)	Annex contemplating an extension regarding evaluation activities of the tools

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List of Abbreviations & Definitions

Abbreviation	Definition
API	Application Programming Interface
AR / VR	Augmented Reality / Virtual Reality
cMDF	Collaborative Manufacturing Demonstration Facilities
GDP	Generative Design Platform
KPI	Key Performance Indicator
MMC	Manufacturers, Makers and Consumers
OpIS	Open Innovation Space
PAT	Process Automation Tool
SME	Small and medium – sized enterprises
SMS	Social Manufacturing Space
UC	Use Case
UI	User Interface
UX	User Experience

Executive Summary

The deliverable D9.3 is the result of the work performed by partners in the evaluation activities of the tools that comprise the Open Innovation Space (OpIS) of the iPRODUCE Social Manufacturing Framework. The evaluation was carried out by the members of the different cMDFs (collaborative Manufacturing Demonstration Facilities) and other iPRODUCE partners, with the objective of retrieving feedback in two different rounds, measuring the level of user satisfaction and meeting with the cMDFs requirements to achieve an incremental improvement.

Previous activities in the scope of WP9 "Validation, Demonstration and Evaluation of the iPRODUCE Social Manufacturing Space" defined the methodology for the platform's assessment.

The evaluation is done by following the heuristic assessment approach which, on the one hand, is focused on the evaluation of the tools in an isolated way, and on the other hand the KPI-based assessment provides a comprehensive vision of the assessment at CMDF level. In addition to all the activities related to the experimentation and evaluation of the tools, the impact of the use of the different components – mainly from the cMDF perspective – is also evaluated to measure to what extent the adoption of the OpIS components meets the expected requirements of the use cases defined in each cMDF.

The heuristic assessment at the mid-term concluded the need for improvement of all the tools taking part of the OpIS platform to meet the appropriate level of user satisfaction. Charts have been provided to illustrate this issue. The final round assessment revealed similar findings, so virtually all the tools under consideration needed specific enhancements to get the level established as fully satisfactory from the user experience perspective. However, the overall ratings were improved, and many problems found in the tools during the experimentation were solved.

Furthermore, the KPI assessment, which provides a comprehensive picture of the fulfillment of the expectations of the use cases and prototypes of the local cMDFs, concluded that the functionalities offered by the OpIS platform of iPRODUCE were satisfied to a large extent. Even considering that the collection of the KPI measurements became a daunting task for the communities due to the delay of the releases of some tools, the adoption of the platform enabled the collaboration between partners involving more participants, improving the generation of new ideas, and facilitating the production of the prototypes for the different use cases. This has been also achieved through the arrangement of meetings and hackathons that also served to collect valuable user feedback about the usage of the platform, which was reported to the developers of the corresponding tools.

It should be noted the inclusion of a D9.3 annex, driven by the need to report the development effort made by the technical partners to improve most of the tools of the OpIS platform and the latest evaluation activities performed by the members of the cMDFs during the ending period of the project. It was considered the need to elaborate this report, so this refines in a very positive way the conclusions - mainly in terms of the heuristic evaluation - gathered after the evaluation rounds reported in this document, providing a more reliable and comprehensive perspective of the status of the tools at the end of the project from the perspective of the cMDF users.

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List of Abbreviations & Definitions

Abbreviation	Definition
AR / VR	Augmented Reality / Virtual Reality
cMDF	collaborative Manufacturing Demonstration Facility
KPI	Key Performance Indicator
MMC	Maker, Manufacturer, Consumer
OpIS	Open Innovation Space
SME	Small and Medium Enterprise
SMS	Social Manufacturing Space
UC	Use Case
UX	User Experience

1. Introduction

WP9 focuses on the validation, demonstration, and evaluation of the tools from the iPRODUCE Social Manufacturing Space, emphasis in the application of these tools to the different cMDFs. Each cMDF covers one specific country and several use cases with its corresponding prototype. This is illustrated in Table 1 below.

Table 1 List of iPRODUCE cMDFs and associated prototypes for validation

Country	cMDF	UC#	Validation prototype
	Collaborative Engineering in Customer-Driven Home Furnishing Products	1	Intelligent Headboard
		2	Smart adjustable gaming chair
		3	3D-printed components for assembling customised furniture
	Open Consultation, Collaborative Product Development, Collaborative Learning	1	Co-Creation – Introduction for SMEs
		2	Machinery Training
		3	Guided Product Development as a Service (GPDaaS)
		4	MSB IoT Education Kit
	Establishment of cMDF in French industrial ecosystem for developing collaborative projects in the automotive/mobility area and associated consumer goods sectors	1	Prototyping equipment tutorials to train and involve FabLab users
		2	Entrepreneurs & SME support to develop new devices in mobility sector
	Collaborative manufacturing environment with cross-competences sharing for product development/enhancement in the microelectronics consumer sector	1	Linear Translation Robo shaker
		2	Distributed Watering System
	Upgrade of the design of a 3D-printed medical equipment including IoT sensors integration	1	IoT-based Orthopaedical back brace
		2	Splints for fractures
		3	Splints for pets
		4	Customised face shields
		5	3D-printed smart luminous artefacts
		6	3D-printed (bio) scaffolds

D9.3 documents the first and final rounds of the validation of the digital platform developed in iPRODUCE, the Open Innovation Space (OpIS), in the scope of the Social Manufacturing Space (SMS), the ecosystem of interpersonal relationships, from the basis for testing, assessing, and validating methodologies documented in previous deliverables D9.1 and D9.2 (Evaluation Methodology, Plan and Metrics I and II).

Due to the bankruptcy of BETAFACTORY, a second amendment was requested during 2022 and the consortium decided to downscale the Danish cMDF trying to recover as much of the approach and work of BETAFACTORY and still providing activity to the Danish Ecosystem. The proposal for this re-structure implied that the project has only 5 full cMDFs but the Danish ecosystem has been involved in the project evaluation mainly in the heuristic assessment through CBS and maintaining the initial KPIs.

As previously introduces in the Executive Summary, it should be remarked the elaboration of the D9.3 annex, that illustrates the latest efforts done by the developers of the tools towards the end of the project to improve both the functionality and the usability of the tools. The annex is conceived as a valuable resource to clarify some aspects of the heuristics assessment and to report the technical work performed by the consortium, considering the main parameters of the evaluation. The annex includes a section describing the latest heuristics assessment and a section that summarizes all the new functionalities added to the different tools involved in the OpIS platform, which indeed has led to an improvement of the satisfaction of the members of the iPRODUCE cMDFs.

1.1. Purpose and Scope

D9.3 reports the heuristic evaluation of the tools that make up the OpIS providing a detailed assessment directly related to the tools in an isolated way. Moreover, this document includes the validation of the Key Performance Indicators (KPIs) defined for each cMDF to provide an aggregated validation targeted to the fulfilment of the proposed prototypes. Both the heuristic and KPIs-oriented validations have been performed in two rounds: one at mid-term (M29) and one as final round (M39). At this point, the main objective became to validate the effectiveness of the developed tools to achieve the main targets of the cMDFs. All the details about how these assessments have been performed are documented in the corresponding sections.

1.2. Relation to other iPRODUCE Work Packages and Tasks

This deliverable is framed within the "Validation of the Digital Platform and Co-creation Tools", Task 9.2. WP9 (Validation, Demonstration & Evaluation of the iPRODUCE Social Manufacturing Space) interacts with most WPs in the project. WP9 is linked to WP2 (Business Challenge Definition for Social Manufacturing in Consumer Goods Sectors) so this WP aligns the project vision with the production models and technologies providing the system requirements, KPIs and the framework of the Open Innovation Space (OpIS). WP9 is also related to WP3 (Establishment of Local Collaborative Manufacturing Demonstration Facilities (cMDFs) where the different local cMDFs are established and WP4 (iPRODUCE Core Services and Digital Platform for Social Manufacturing) so indeed, in such WP the core platform is implemented to be later evaluated in WP9. Further relationships can be considered with WP5 (Customer-Driven Production and Co-Creation Enabling Tools) since WP5 includes components to be evaluated (e.g., Generative Design Platform used for the idea generation process). Also, WP9 is related to WP6 (Social Media-Enriched Engagement Strategies for Makers and Consumer Communities) regarding the mobile app used to evaluate the user feedback, and with WP7 (iPRODUCE Sharing Economy Business Models and Execution Tools) so the business models for every Collaborative Manufacturing Demonstration Facility (cMDF) defined in WP7 affect the validation of the use cases. Finally, the relationship of WP9 with WP8 (iPRODUCE Integrated Social Manufacturing Space) is based on the Social Manufacturing Space (SMS) which is a centrepiece in WP9 for the acceptance testing of the iPRODUCE platform as a whole. These relationships are succinctly depicted in Figure 1 below.
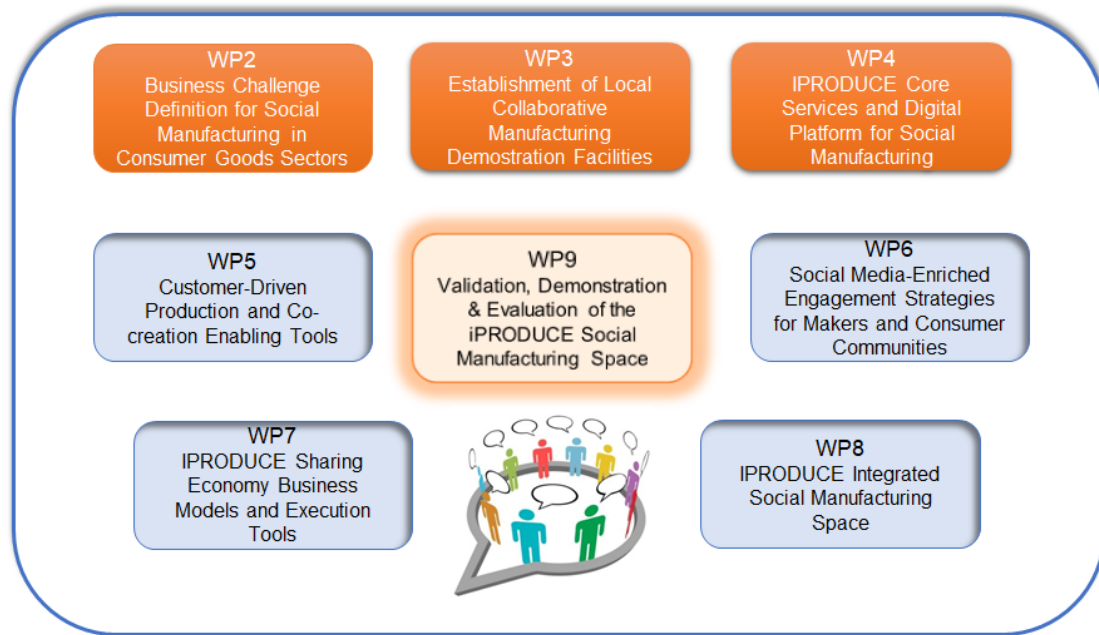
Figure 1 Relationship between WP9 and the rest of WPs

1.3. Structure of the Document

This document includes four main sections apart from the present introductory section. First, the Evaluation Methodology section explains the process followed up for the heuristic evaluation, reminding the basis defined in D9.1. Then, the Heuristic Assessment section includes the detailed evaluation for each tool in the iPRODUCE context, with a clear distinction between the mid-term and final evaluation rounds and a clear attention to the improvements achieved. A similar approach is followed later in the Validation through KPIs section, where the assessment is performed at a higher level considering each cMDF as a whole and reporting its implementation adopting the offered developments. Just after this, the main conclusions include the most important remarks for both the heuristic and the KPI-based assessments, to provide a summarised vision of the experimentation. Finally, the OpIS Map section illustrates the adoption of the different tools for every use case in every cMDF, a comprehensive picture that gives valuable insights on the level of dependency of each prototype regarding the tools of the OpIS platform. It should be reminded the inclusion at the end of the document of the annex that reports the latest enhancements made in the tools during the last period of the project, addressing the comments provided by the users during the heuristic evaluations.

2. Evaluation Methodology

2.1. Heuristic assessment approach

2.1.1. Introduction to the Heuristic Evaluation

The heuristic evaluation is a usability engineering method for finding problems related to usability in the design of a user interface following an iterative design approach. This method involves a small set of evaluators who examine the interface and evaluate its compliance based on recognized usability principles, called the heuristic [2].

The Figure 2 below shows the usability problems found by evaluators in a heuristic evaluation of a banking system. The rows represent the evaluators (19) and the columns represent the usability problems (16). Each dark square represents the finding of the corresponding usability problem by the corresponding evaluator. The rows are sorted so the most successful evaluators are at the bottom and the least successful are at the top. The columns are sorted so the usability problems that are the easiest to find are on the right while the most difficult to find are on the left [2].
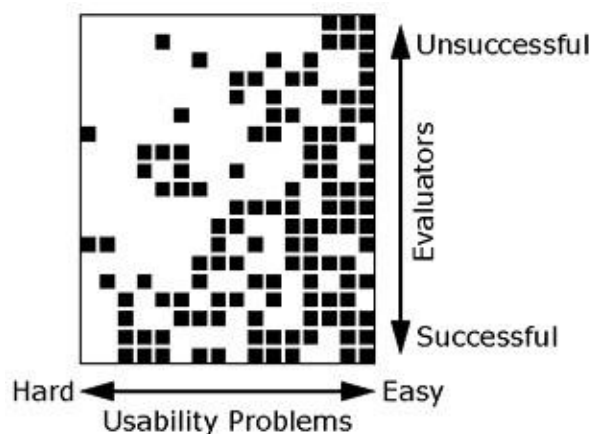
Figure 2 Exemplary depiction of usability problems detected by evaluators

The assets required to perform a basic heuristic evaluation include 3 to 5 evaluators with heterogeneous expertise in digital products, a group of expert users that could assist the evaluators, and 10 usability heuristic to be assessed. During this process, it is important that the evaluators perform the assessment individually to correlate the findings and remove duplicates at the end. It is also recommended that the evaluators perform an analysis of the entire product multiple times to assess the main aspects of the system, which mainly are the information architecture, the visual design, the navigation, the functionality, the design of the interaction, and the content. The findings are classified in the categories *High*, *Medium* and *Low*, based on the level of impact that they have in the user experience [3].

The main advantages of a Heuristic Evaluation [4]:

- Reveals many usability problems that improves the user experience.
- Is cheaper and faster than massive usability tests that involve the coordination of many participants.
- Helps the evaluators to focus on problems.
- Does not carry ethical and practical issues related to inspection methods that involve real users.
- Evaluates the design taking a set of heuristic that helps to identify usability problems with concrete user flows determining the impact on the overall user experience.

The main disadvantages of a Heuristic Evaluation [4]:

- Usability experts are often hard to find and expensive to involve.
- The value of the detected issues depends on the skills of the corresponding evaluator.
- The analysis sometimes triggers false alarms (issues that do not have necessarily a negative effect on the overall user experience are often just marked to be fixed).
- The evaluation is based on predetermined notions of what "good" usability implies.
- Evaluators are often not part of the design or development team, which means that they are not aware of technical limitations of the design.

2.1.2. Evaluators' profiles

The heuristic evaluation can be performed by individual evaluators. However, this approach often provides poor results. If different evaluators tend to find different problems, it is possible to achieve better results by aggregating the evaluations from several evaluators.

Figure 3 below illustrates how the detection of usability problems improves when more evaluators are involved. In the light of the graph, it is reasonable to consider the involvement from three to five different evaluators. This may depend on the critical level of the usability of the system.
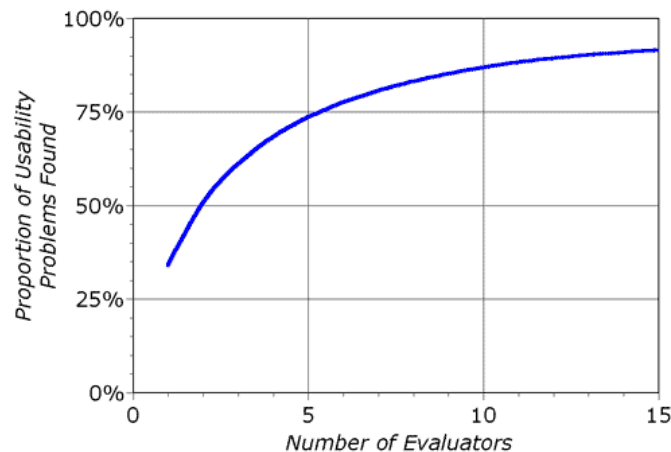
Figure 3 Detection of usability problems depending on the number of evaluators involved

The model based on the prediction formula below presented by Nielsen and Landauer [5] enables the estimation of the usability problems found in a heuristic evaluation:

$$Problems\_found = N(1 - (1 - l)^i)$$

where problems were found, the (i) represented the number of usability problems detected by aggregating the evaluation of i independent evaluators, N represented the total number of usability problems, and (l) indicates the ratio of problems detected by a single evaluator [2].

To perform a cost-benefit model of heuristic evaluation it is recommended to determine the optimal number of evaluators, considering both variable and fixed costs. Whilst variable costs are those independent from the number of evaluators (i.e.: costs related to get the materials, results reporting), the fixed ones are those which are increased every time a new evaluator is involved (i.e.: the expenses for the dedication of the evaluators). Both types of costs depend on the system to be evaluated and the structure of the company.

Although the direct benefits of this methodology come from the detection of usability problems, the evaluators may also increase their understanding of usability through a continuous education by comparing their reports with those from others. The value of finding usability problems varies

depending on the user population. In this regard, when the software implemented is conceived to be used only in the internal scope of a company, the considered value would consist in the increase of the user productivity. When the software is expected to be sold, the value can be estimated based on the increase of sales achieved from a higher user satisfaction.

It should be noted that the real value comes from problems which are finally fixed, so considering that not all usability problems can be fixed, the value of each problem detected is part of the value of the problem that has been fixed.
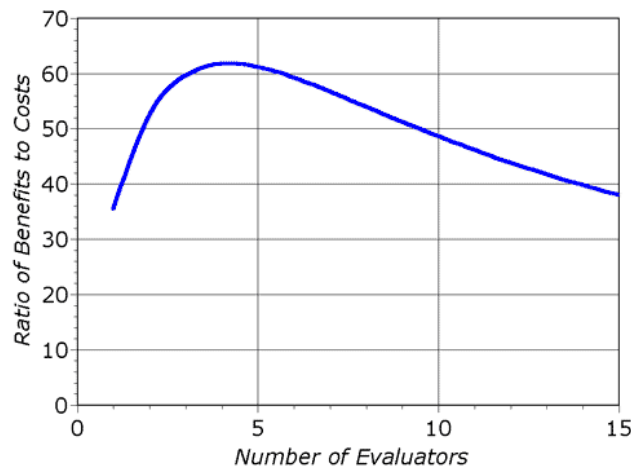
Figure 4 Graph depicting how many times the benefits exceed the costs in a heuristic evaluation

The Figure 4 above shows the variation of the benefits to the costs involving different numbers of evaluators. In the depicted example, it can be deduced that the optimal number of evaluators is 4, which confirms the statement that heuristic evaluation works best from 3 to 5 evaluators involved [2].

2.1.3. The Heuristic Principles

This section enumerates the list of default heuristic principles [3]:

(i)   Visibility of system status

The status of the system should always be prompted to the user at any moment. A user who is always aware of the status of the system can know the impact of previous interactions as well as determine the next steps to be performed in the system. If the system needs some time to refresh this information and render it to the user, this period should be as short as possible.

(ii)   Match between system and the real world

The way the system communicates with the user should be familiar to the user taking the real world as reference. The information should appear in a natural and logical order. Words, concepts, iconography, and pictures should be understandable by the users, avoiding the need of users having to find out the meaning.

(iii)   User control and freedom

Users should be able to 'undo' and 'redo' actions to some extent and exit the system easily. The exit from any area needs to be clearly indicated to avoid the users to perform complex workarounds to this end.

(iv)   Consistency and standards

The system must adopt standards in the interface as much as possible, using conventions that are potentially familiar to the users. In the scope of the system, the same concepts should be used when they represent the same meaning. This leads to an internal and external consistency.

(v) Error prevention

The system should support the users in avoiding human errors as much as possible. Errors can be classified in two categories: (i) slips - which are errors caused by inattention - and (ii) mistakes - caused by some lack of understanding about how the system is conceived to work. Slips can be avoided by providing constraints and default values, while mistakes can be prevented by removing burdens and providing the 'undo' functionality and quality warning messages. Appropriate error messages become very important and confirmation options to warn the users before committing critical actions are required.

(vi) Recognition rather than recall

In order to avoid the overloading of the memory of the user, the system must provide user assistance. Key elements, labels and options should be made always visible. The system may offer help in context instead of long tutorials.

(vii) Flexibility and efficiency of use

The system must be efficient for both novice and experienced users. The availability of shortcuts for experienced users, as well as alternative options for the novice users is recommended. The personalization provides tailored content for users, while the customization capability allows users to adapt to some extent how the system works for them.

(viii) Aesthetic and minimalist design

Only the most relevant data should be presented to the user. This allows the system to acquire the attention of the user effectively. The presence of extra information units in the interface reduces the visibility of the relevant ones. This does not imply to implement a flat design, but an interface that keeps the user focused on the essentials.

(ix) Help users recognize, diagnose, and recover from errors

The system must support the users to recover from errors, prompting friendly messages. The presence of error codes should be avoided, indicating a clear message about the problem and some solution suggestions instead. The use of illustrative icons may support this topic, as well as some shortcut that could allow the user to save the situation in an agile manner.

(x) Help and documentation

The system should provide appropriate online/offline help documentation explaining the system through effective steps oriented for the users to achieve their objectives. This documentation should be easy to search, concise, and focused to particular tasks.

2.1.4. Execution of the Heuristic Analysis

Each of the iPRODUCE OpIS tools were evaluated using the 10 heuristic parameters. The evaluation of each parameter involves a short collection of related questions that have been answered by the evaluators of the tools.

It should be noted that not all evaluators could evaluate all the tools. Therefore, the score has been calculated based on the retrieved answers. To make the scores more illustrative, 3 different levels

have been defined. This way, according to the gathered answers, each question is annotated as "PASSED", "ROOM FOR IMPROVEMENT" or "FAILED", also represented with a colour code of green, yellow and red. These annotations are assigned based on the percentage criteria indicated in the following Table 2:

Table 2 Acceptance criteria based on percentages

PASSED	>75% of positive feedback
IMPROVE	From 74% to 50% of positive feedback
FAILED	<50% of positive feedback

Given that all the questions related to each parameter have the same weight in terms of relevance, all these answers are put together to calculate the definitive score.

Figure 5 below shows a proposal of workflow of the usage of the tools from the user perspective that can be followed in the experimentation by the cMDFs.
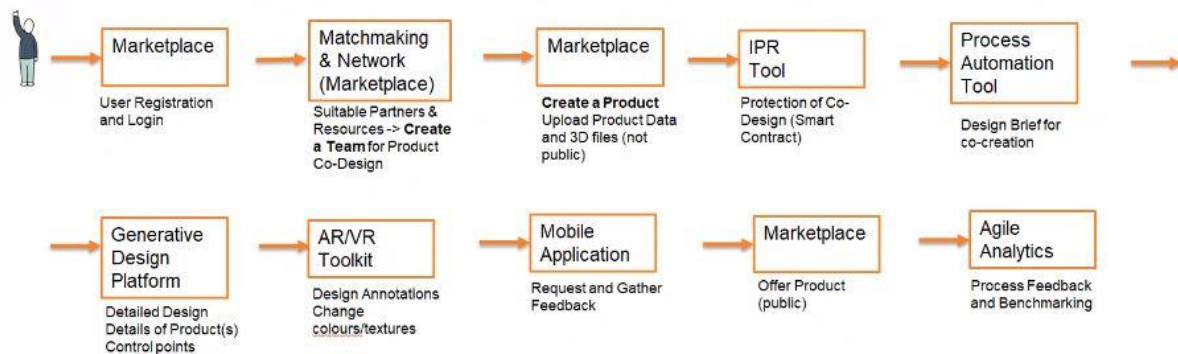
Figure 5 Overall workflow of involvement of the tools

To provide the user feedback to the technical partners in a short term, an intermediate report after the mid-term evaluation was generated and shared with the consortium. Indeed, the mid-term reporting document released to the technical partners corresponded to the mid-term evaluation sections of each tool included in the actual deliverable.

Table 3 below shows the list of partners and number of evaluators involved in the mid-term and final evaluation of the tools.

Table 3 Partners and number of evaluators involved in the heuristic assessment

Partner	#Evaluations mid-term	#Evaluations final
AIDIMME	2	5
CBS	1	2
F6S	1	1
LAG	1	1
MAT	1	1
MSB	1	-
TS	1	1
VLC	1	1
VOSGES	1	1
TOTAL	**10**	**13**

As a summary, the Table 4 below shows the list of tools of the iPRODUCE's OpIS platform evaluated in an isolated way in the heuristic assessment, including a short description about each of them to provide the scope to the reader before its corresponding evaluation results.

Table 4 Short summary of the OpIS platform tools evaluated

Name of the tool	Short description
Generative Design Platform (GDP)	This tool consists of 4 tools. - Products: Product creation and list of the products created in the marketplace. - 3D Configurator. Tools used to modify and create 3D objects. - 2D layout. Create /load a composition in 2d environment and display them in 3D. - Spatial Instructor. Create 3D objects by commands.
IPR & Transaction Management	It creates a default contract for negotiation between the users of a team with blockchain technology.
MarketPlace	Creation and management of users. Creation of teams, cMDF members administration, search for users or products in the platform, creation of individual and collaborative products.
Matchmaking (inc. Agile Network Creation)	This tool helps to find users for creation of a collaborative team filtering by location, skills and sector and free text.
AR (Mobile App Client)	It displays the 3D models in the real world (AR) modify colours and materials.
VR (VR Client)	It displays and modifies 3D files from the collaborative team or public products. Display the 3D models in virtual space, create a composition with different 3D models in a room.
Mobile App for Social Media	It creates surveys and sends them to a team.
Agile Data Analytics and Visualization Suite	This tool is used to visualize data from the platform, and to check the results of the surveys.
Video Intelligence	It performs analysis of videos (transcribing and object detecting with AI services) and segmentation of video recordings, and process textual search requests through the video. The search is performed over the contents of audio tracks as well as over the objects detected within the video.
CMDF Training Flow	The cMDF Training Flow provides educational and training scenarios for workers. It creates a training flows by Drag n Drop graphical tools to help in training scenario creation.
CMDF Training View	This tool provides a step-by-step presentation of training scenarios through mobile interfaces, 3D Visualisation of the assembly, and usage process for the equipment featured in the training scenarios.

Process Automation Tool	It supports the creation of prototype process using requirements, the creation of design briefs, and the collaboration between manager, designer and client.

As can be deduce from the previous descriptions, the heuristic methodology has its advantages and disadvantages, considering the iPRODUCE's scope. On the one hand, as main advantage, this approach is sufficiently attractive to engage users in the evaluation process, so the principles cover the main topics in a clear and precise way, also without the need of involving a great number of evaluators. On the other hand, the main disadvantage is the interpretation of the different principles and its associated questions by the evaluators, so, despite the descriptions of the different parameters could be expressed in an accurate manner, there is always a significant scope for interpretation which may lead to distortion. However, in practice this potential distortion has not a great impact on the results, and the benefits of adopting the heuristic assessment to evaluate the tools of the OpIS platform in iPRODUCE and involve users largely outweigh this disadvantage.

2.2. Evaluation methodology reminder

As commented earlier in the introduction, the evaluation has been done based on methodologies described in deliverables D9.1 and D9.2 (Evaluation Methodology, Plan and Metrics I and II). This focuses on the comparison between the AS-IS situation and the TO-BE one, after the adoption of the tools of the OpIS platform. It should be noted that the present validation covers, to some extent, a collection of heterogeneous cMDFs that do not always use the same components, so they belong to different environments and consider different objectives.

The KPIs selected for each cMDF has been defined according to the simplified ECOGRAI method which is explained in detail in D9.1. The evaluation aims at covering both quantitative and qualitative aspects. The user experience (UX) is gathered from the questionnaires in which the users can set, for each tool, if the tool passes or fails every heuristic principle and, for each one, add comments regarding the experimentation to provide a more refined response. These comments have been particularly useful for the tools' developers to better understand the context of the released evaluations.

The definition of a cMDF Use Case consists of the definition of the stakeholders, the interaction with the OpIS platform components, and the means of evaluation used to measure each component. In this regard, the application of a KPI is relevant just if its value is affected by the adoption of such a component.

Besides this, the OpIS Map which supports the validation process, is in the form of a spreadsheet. The main objective of this map is to provide a quick overview of WHO interacts with WHAT. The spreadsheet includes all the Use Cases, indicating the prototype to be validated, together with the stakeholders involved and the list of OpIS components that interact with the Use Cases. The methodology must be able to support dynamic changes so, during the evaluation period, some cMDF may find that another OpIS component is not yet going to be used, or replaced by another different component, or the involvement of stakeholders may change.
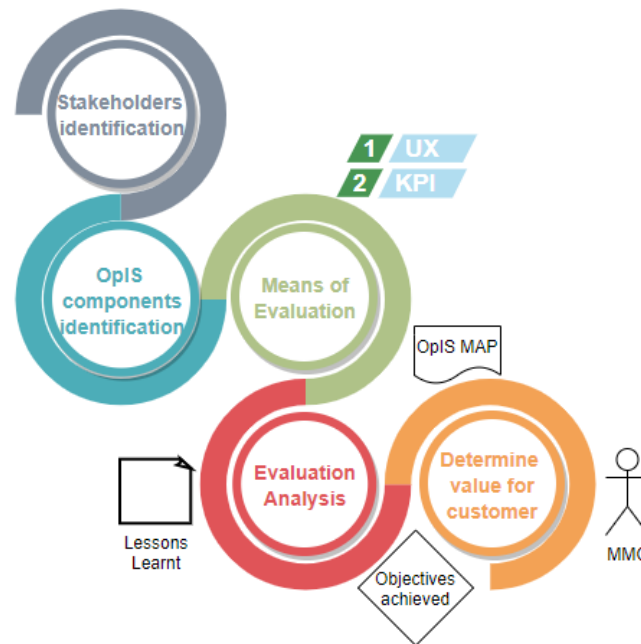
Figure 6 Overall view of the Evaluation Methodology in iPRODUCE

The Figure 6 above shows the evaluation methodology flow diagram. The stakeholders belong to the MMC (**M**anufacturers, **M**akers, and **C**onsumers) communities and interact with the OpIS components adopted in such use case. They play the role of evaluators deciding if a component is appropriate or not for each use cases. The OpIS components are the main gear devices that facilitate all the collaborative production engineering. Each cMDF identifies the components to be adopted in its use cases based on the specification of the components and expectations from the use case perspective. As means of evaluation, questionnaires are used to capture the interactions of the stakeholders with the components. The questionnaires gather the experience and opinions of the users during the development of the cMDF. The users' feedback is addressed in a different way depending on whether this is retrieved from questionnaires or interviews, so the questionnaires provide closed response options while the interviews enable the gathering of refined qualitative information about the users' perception. It should be noted that KPIs are also used in the evaluation. Each use case defines at least one indicator connected to a component, so just those KPIs that are relevant for the use of a component will be considered.

When the evaluation is completed, evaluation scores are extracted and analysed to determine if a given OpIS component meets the intended use and need. Although questionnaires and interviews provide more subjective and direct feedback on particular stakeholders, and KPIs provide a more objective measurement. The evaluation allows to collect lessons that may lead to the generation of new ideas for improvement and development. The evaluation between local cMDFs should be considered to observe how the platform is able to support the collaboration in a cMDF network.

The application of the methodology assesses not only the adequacy of the components in the use cases but the value of these components for the customers. This is indeed the objective of the current evaluation report.

3. Heuristic Assessment

The next sections navigate inside each one of the evaluated tools providing an overall score table calculated from the user assessment. In the beginning of each tool section, the number of evaluators and the average overall scoring is indicated. It should be noted that not all questions could be answered by all the evaluators. Therefore, the score is calculated based on the positive/negative answers, without considering those that users could not submit and left unanswered. Also, if the user posted a comment indicating that such questions could not be properly assessed, this has not been considered for the final score. This applies to the error management, so this depends a lot on the specific usage scenario of the tools. The end of each tool chapter includes insightful comments by users organised in those aspects that the tool is failing or could be significantly improved.

3.1. Generative Design Platform (GDP)

3.1.1. Midterm Evaluation

The overall score of this tool was 64,64, with the involvement of 10 evaluators. The scores of the tool based on the heuristic´s principles are shown below:

Table 5 Score by heuristic principle of Generative Design Platform (mid-term)

1. Visibility of system status	**80,00**	**PASSED**
2. Match between system and the real world	**82,22**	**PASSED**
3. User control and freedom	**62,50**	**IMPROVE**
4. Consistency and standards	**95,00**	**PASSED**
5. Error prevention	**40,00**	**FAILED**
6. Recognition rather than recall	**75,00**	**PASSED**
7. Flexibility and efficiency of use	**53,33**	**IMPROVE**
8. Aesthetic and minimalist design	**95,00**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**16,67**	**FAILED**
10. Help and documentation	**46,67**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

Users could not undo some actions in the spatial instructor, and it is not clear for them how to delete an element in the 2DLayout clicking in SUPR. In the 3D configurator, 2D Layout, there is no 'default' option to set values back to its original state. The home button is always visible at the top, but the iPRODUCE logo links to the login page, when it should link back to the main navigation. Indeed, it is not clear that the "home" icon is the way to "undo" or "go back". There is no easy access to all options unless the users navigate to 'Home'. The main menu should always be present somehow. If users are modelling an object, they struggle to know how to exit that screen and go back to the main menu. In the end, the feeling of users is that the tool is very lenient towards expert and experienced users.

5. Error prevention

Some errors sometimes occur when users modify the 3D model in the 3D configurator, leading the model to get blocked, with no notification prompted and forcing it to restart the model. The lack of feedback when some selections are made has also been detected. The UI is much oriented to experts, so the information is not clear enough for regular users. Users would appreciate more feedback and guidance.

7. Flexibility and efficiency of use

Regarding the seventh principle, when users make changes to the product, no save button but just a share option is available. Sometimes the 3D configurator and the spatial instructor gets blocked, and in addition, the spatial instructor often works really slow. The response time is acceptable when navigating on menus, but not the case when modelling the objects. There is no contact information or contact button. The question mark icon on the right top corner gives the impression that users can ask questions or contact the technicians, but the button automatically downloads a user guide file. Such an icon is therefore not appropriate. In the end, no contact is available, or at least users could not find a way to request support or submit questions.

9. Help users recognize, diagnose, and recover from errors

Regarding the ninth principle, users did not visualise h error messages, notifications, or feedback. In some cases, an error kept popping up "failed to initialise " and the user could not be aware of what this error was about. The user just pressed "ok" and then it disappeared. Besides this, errors caused by the user when not using the system properly (i.e.: try to upload any file different than a .jpeg) are properly notified.

10. Help and documentation

Users could not find help documentation, but only the user guide through the question mark icon on the top right corner. No help button is available for navigating any additional guidance documentation.

3.1.2. Final Evaluation

The overall score of this tool has been 59,51, which is lower than the score obtained in the mid-term evaluation - with the involvement of 11 evaluators. The scores of the tool based on the heuristic´s principles are shown below:

Table 6 Score by heuristic principle of Generative Design Platform (final)

1. Visibility of system status	70,91	IMPROVE
2. Match between system and the real world	81,21	PASSED
3. User control and freedom	54,55	IMPROVE
4. Consistency and standards	84,34	PASSED
5. Error prevention	22,73	FAILED
6. Recognition rather than recall	75,00	PASSED
7. Flexibility and efficiency of use	52,39	IMPROVE
8. Aesthetic and minimalist design	81,82	PASSED
9. Help users recognize, diagnose, and recover from errors	11,57	FAILED
10. Help and documentation	60,61	IMPROVE

The most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

1. Visibility of system status

For some users, the state is not visible enough, but other consider that the user can watched the logged in status properly. However, most of them find the response time rather slow, and the system does not present any indication of the loading process, and also lacks information feedback in most cases. Therefore, a better UX could be achieved if the options would be represented as buttons with some mouseover indication.

3. User control and freedom

Users could not find a way to undo changes while playing with the design of a chair. The option 'back' is present, but it is not clear if this option navigates to the previous page. The undo option is present only in the '2D Layout' but did not work properly. However, the way to navigate through the different areas of the system is presented in a clear way and the option to return Home is easy to find.

5. Error prevention

Although for some users the information on how to perform actions is clearly displayed if needed to avoid errors when using the system, for other users the errors are not clearly explained, with no information about charges available, and using the tool is basically a trial-and-error task. Also, no information pops up when hovering the cursor over the buttons. This would be helpful to avoid mistakes by users. The Spatial Instructor is not clear, and the documentation is from the old version. It is mandatory to go through the user guide to understand what and how to use it. When using the 3D Configurator some problems are detected. The models take too long to load, and users do not know if this is loaded or not. Maybe this is why a '502 Bad Gateway' error often appears when clicking on them. It is still quite difficult to use when the user is not familiar with the tool. There is supposed to be a guideline available but this could not be found. The tool does not indicate information about the steps to follow in the GDP.

7. Flexibility and efficiency of use

The tool is too slow when rendering 3D images and moving them in the app, and the user needs to wait for the username to be loaded every time. There is no contact information available.

9. Help users recognize, diagnose, and recover from errors

An "Error 500 no information" message is prompted when errors occur, but no further error descriptions are provided to the users.

10. Help and documentation

Just having a long PDF as a User Guide is not useful when trying to find a specific response. The text could be improved so any user can easily understand what the GDP does. The documentation does require an update. There is a general guide available, but a step-by-step guide into the different modules will be useful.

3.1.3. Improvements achieved

The connection between GDP and the Marketplace was improved. Thanks to new updates, the users can inspect the profile of the product created in the Marketplace in GDP. When the user creates a product in GDP the product is also created in the Marketplace. Also, the 2D to 3D headboard generation was enabled and added the image of texture. Moreover, the Spatial Instructor was redesigned, and several bugs repaired.

3.2. IPR & Transaction Management

3.2.1. Midterm Evaluation

The overall score of this tool has been 56,43, with the involvement of 10 evaluators. The scores of the tool based on the heuristic´s principles are shown below:

Table 7 Score by heuristic principle of IPR & Transaction Management (mid-term)

1. Visibility of system status	**76,00**	**PASSED**
2. Match between system and the real world	**83,33**	**PASSED**
3. User control and freedom	**65,63**	**IMPROVE**
4. Consistency and standards	**83,33**	**PASSED**
5. Error prevention	**46,43**	**FAILED**
6. Recognition rather than recall	**60,71**	**IMPROVE**
7. Flexibility and efficiency of use	**53,17**	**IMPROVE**
8. Aesthetic and minimalist design	**81,25**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**11,11**	**FAILED**
10. Help and documentation	**3,33**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

It is difficult for users to find the path and how to generate an IPR contract. Just three navigation options are shown, and home is missing.

5. Error prevention

Some users could not make a new contract and could not find any help for that in the tool. Besides this, if a user edits a contract and two other users accept it, users must accept it again, which for some users may not make sense. Only if some user makes any real changes to the contract, then this would need to be accepted again by other users.

6. Recognition rather than recall

While the home page is clean and easy to navigate for some users, they could not assess the other pages (e.g., Dashboard is an empty page with just the iPRODUCE logo). Furthermore, there is no search option available.

7. Flexibility and efficiency of use

Users pointed out that there is no contact information, and the search box just accepts 9 characters.

8. Aesthetic and minimalist design

The content and design of the interface is not always focused on the most important and sometimes it is difficult for users to find all the functionalities.

9. Help users recognize, diagnose, and recover from errors

It should be noted that most users could not fully assess this aspect so there was no room for errors during the experimentation.

10. Help and documentation

Users could not find any documentation of the system.

3.2.2. Final Evaluation

The overall score of this tool has been 65,70, with the involvement of 12 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 8 Score by heuristic principle of IPR & Transaction Management (final)

1. Visibility of system status	**76,67**	**PASSED**
2. Match between system and the real world	**86,11**	**PASSED**
3. User control and freedom	**61,93**	**IMPROVE**
4. Consistency and standards	**83,33**	**PASSED**
5. Error prevention	**66,67**	**IMPROVE**
6. Recognition rather than recall	**72,08**	**IMPROVE**
7. Flexibility and efficiency of use	**64,39**	**IMPROVE**
8. Aesthetic and minimalist design	**95,83**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**50,00**	**IMPROVE**
10. Help and documentation	**0,00**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

Users were not able to delete a contract, and the logo does not link to the main page, as well as no 'back' buttons are available. However, other users could find it clicking on the 'escape' option. Some difficulties to navigate the different areas were found, mainly between the dashboard and the actual contract. Sometimes it is quite hard to know in what part of the tool the user is located, and the button for going Home did not seem to work.

5. Error prevention

No indicators about some errors were found, as well as no information about how to recover, retreat or even create a new contract. The navigation results are a bit complicated (i.e.: cannot define a contract type, and when the system requests feedback, does not provide options). Although for some users the tool is intuitive enough, for others a guide or information would have been nice to have.

6. Recognition rather than recall

There is a lack of contextual help. Considering the type of tool, more information would be recommended. But the search option is easy to find if this is required.

7. Flexibility and efficiency of use

Some users could not access a contract, and no customisation options were found. If there are many contracts, the tool takes too long to load and sometimes nothing is displayed. The contact information is only available through the iPRODUCE website, but the system does not present broken links.

9. Help users recognize, diagnose, and recover from errors

Sometimes the way to fix the problem is not evident for the users.

10. Help and documentation

No documentation was found.

3.2.3. Improvements achieved

The frontend of the IPR & Transaction Management Tool was redesigned. From the last updates, the users involved in the creation of the contract are displayed and it is easy to see the information of the profile (i.e.: name, email, location, picture). Furthermore, the online chat was enabled, as well as the videochat, the sharing contract functionality and the timeline of the contract. Multiple options for better UX were added, repairing the bugs encountered.

3.3. MarketPlace

3.3.1. Midterm Evaluation

The overall score of this tool has been 69,68, with the involvement of 11 evaluators. The scores of the tool based on the heuristic´s principles are shown below:

Table 9 Score by heuristic principle of Marketplace (mid-term)

1. Visibility of system status	85,45	PASSED
2. Match between system and the real world	81,82	PASSED
3. User control and freedom	77,27	PASSED
4. Consistency and standards	100,00	PASSED
5. Error prevention	59,09	IMPROVE
6. Recognition rather than recall	54,55	IMPROVE
7. Flexibility and efficiency of use	54,55	IMPROVE
8. Aesthetic and minimalist design	100,00	PASSED
9. Help users recognize, diagnose, and recover from errors	75,00	PASSED
10. Help and documentation	9,09	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

5. Error prevention

No red notification in fields is prompted when publishing a product. It is needed to ask for confirmation, for example when sending invitations to arrange a team. It is not clear who should receive such invitations. Other users point out that the system lacks much information, for example about how to save the product data.

6. Recognition rather than recall

For some users the elements in the interface are quite illustrative except for the icon referring to "jump to optimiser".

Regarding the context help, this is missing so no labels are available. The search input box just accepts 9 characters. It is not clear for users how to search for either a product nor a user. They can watch a list but there are no filters available (e.g., alphabetical order, creation date).

7. Flexibility and efficiency of use

The content can be customised only in the profile edition. Users consider that loading products takes too long. Overall, the response time can be acceptable except for the "VR" option. Besides this, users were not able to contact for support. No contact is available or easy to support to ask for support and submit questions. Some parts of the tool show an "under construction" message while some tabs and links are not working.

10. Help and documentation

There is no help button available for extra guiding documentation.

3.3.2. Final Evaluation

The overall score of this tool has been 73,32, with the involvement of 13 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 10 Score by heuristic principle of Marketplace (final)

1. Visibility of system status	**89,23**	**PASSED**
2. Match between system and the real world	**84,62**	**PASSED**
3. User control and freedom	**82,21**	**PASSED**
4. Consistency and standards	**96,15**	**PASSED**
5. Error prevention	**65,91**	**IMPROVE**
6. Recognition rather than recall	**78,85**	**PASSED**
7. Flexibility and efficiency of use	**58,33**	**IMPROVE**
8. Aesthetic and minimalist design	**92,31**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**67,68**	**IMPROVE**
10. Help and documentation	**17,95**	**FAILED**

Most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

5. Error prevention

Users could not find information about how to upload products.

7. Flexibility and efficiency of use

There were no notifications indicating that a message had been received and problems were also found trying to contact another user directly. Also, some users found that there was no button on the Teams tab to create a new team, nor a button on the Products tab to create a new product. Users could not find a way to present the information in a personalised way. Regarding the response time, this is not considered as acceptable when navigating to the VR mode. The tool seems to lack an option to change the password, and the 'about' button was not working to get some contact information, as well as other present links.

9. Help users recognize, diagnose, and recover from errors

The mandatory obligatory fields when creating a new product are not indicated. It would be recommended to change colour or be indicated with some special symbol. Also, an error was found when moving to the VR mode. This was automatically solved, but the user could not understand what the error message meant.

10. Help and documentation

No documentation was found.

In addition to all the previous issues, directly aligned to the heuristic criteria, the users indicated some suggestions for this Marketplace tool: on the one hand, when users exchange messages, the recipient does not receive an e-mail from the platform, no animation or relevant information about the reception of new messages is sent, and it is not possible to send messages to other users. In the end the process is not intuitive at all. On the other hand, when creating teams, the new teams do not automatically appear to the user in the list, and when clicking in the 'Matchmake' option, the user cannot return to the Marketplace.

3.3.3. Improvements achieved

A new more user-friendly frontend was implemented. The cMDF Community was added together with the option for users to request for join it. The tool also provided new functionality to manage the requests related to each cMDF. Changes were made on the view-product profile. Connectivity between the Marketplace and the other iPRODUCE tools was added. From the last updates, users could be added after creating a Team. The user profiles can also be edited (i.e.: skills, views, company/FabLab name) and accounts can be deleted. It is also possible to register again using the same email address after removing the account. Several bugs were fixed, and tooltips with information about the usage of the tool have been added.

3.4. Matchmaking

3.4.1. Midterm Evaluation

The overall score of this tool has been 58,64, with the involvement of 9 evaluators. The scores of the tool based on the heuristic principles are indicated below:

Table 11 Score by heuristic principle of Matchmaking (mid-term)

1. Visibility of system status	**76,94**	**PASSED**
2. Match between system and the real world	**92,59**	**PASSED**
3. User control and freedom	**72,22**	**IMPROVE**
4. Consistency and standards	**77,78**	**PASSED**
5. Error prevention	**46,53**	**FAILED**
6. Recognition rather than recall	**77,78**	**PASSED**
7. Flexibility and efficiency of use	**44,44**	**FAILED**
8. Aesthetic and minimalist design	**72,22**	**IMPROVE**
9. Help users recognize, diagnose, and recover from errors	**22,22**	**FAILED**
10. Help and documentation	**3,70**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

User pointed out that the back link/option on the top right corner is broken. The messages cannot be deleted or edited, and a simple sending of a message cannot be deleted. Initially, the navigation works but it is not possible to move past the search phase. In addition, users miss filters for doing searches.

5. Error prevention

While some users state that there is not enough live material to assess this aspect of the tool, others consider that the principle is not fulfilled, which returns an overall negative rating. However, errors caused by user mistakes, such as the entering of the wrong password or an existing username are properly indicated.

7. Flexibility and efficiency of use

The system does not present standard options that could help an inexperienced maker in the search of potential partners. Users do not watch many customisation options and consider that the matchmaking functionality does not work properly.

8. Aesthetic and minimalist design

Users consider that the UI needs to be improved. The content and design of the interface is not focused enough on the most relevant aspects.

9. Help users recognize, diagnose, and recover from errors

While some users state that there is not enough live material to assess this aspect of the tool, others consider that the principle is not fulfilled, which returns an overall negative rating.

10. Help and documentation

User could not find any documentation.

3.4.2. Final Evaluation

The overall score of this tool has been 75.28, with the involvement of 13 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 12 Score by heuristic principle of Matchmaking (final)

1. Visibility of system status	89,23	PASSED
2. Match between system and the real world	94,87	PASSED
3. User control and freedom	74,20	IMPROVE
4. Consistency and standards	96,15	PASSED
5. Error prevention	72,73	IMPROVE
6. Recognition rather than recall	88,46	PASSED
7. Flexibility and efficiency of use	63,58	IMPROVE
8. Aesthetic and minimalist design	96,15	PASSED
9. Help users recognize, diagnose, and recover from errors	69,70	IMPROVE
10. Help and documentation	7,69	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

While selecting people for a team, it is possible to add and remove them easily. Yet, in other screens there is no redo/undo button. The user must use the browser's arrows. There is no option to reset the query or even a link to the iPRODUCE page (which could be on the logo). Also, there were no logout and 'back' options available, preventing going back to the Marketplace.

5. Error prevention

Some error was found when adding a team member with no e-mail address registered, so it was possible to send an invitation to another user to join a team. Also, users could not find an obvious way to solve this issue or go back to find other similar/possible partners. It would be nice to have some information when the user rolls over the products/results.

7. Flexibility and efficiency of use

Regarding the search, it can be considered that there is to some degree of customisation available. However, the tool is often very slow at showing the results from the searching. Users also could not find contact information nor support.

9. Help users recognize, diagnose, and recover from errors

While creating a team and the invitation could not be sent to a selected user, the error message appears very small on the bottom of the page. This could have been more visible and bigger in size and placed centrally to be better noticed by the user. Also, there was no information on how to solve the problem.

10. Help and documentation

No documentation was available.

3.4.3. Improvements achieved

From the last updates, when the user clicks on Matchmaking, this is redirected from Marketplace to the Matchmaking in the same web page and, after creating a Team, the user is redirected to the Marketplace. This improves the UX while navigating through the tool. Moreover, the connection between Matchmaking and Marketplace became better and faster. The database system was improved so the results could be displayed in real time. The frontend was also improved, and tooltips with information about the use of the tool added. Some attributes were also added (i.e.: sectors, skills, country, city). As a result of the latest updates, the ";" character was used to separate the keywords in free text, the teams are displayed in the search results, and information of the user who is using the tool is displayed on the top right side. Besides this, a set of bugs were solved.

3.5. AR (Mobile App Client)

3.5.1. Midterm Evaluation

The overall score of this tool has been 48,24, with the involvement of 5 evaluators. It should be noted that the reason under this low number of evaluators for the AR tool was the need for a compatible smartphone device and the installation process of the tool, what prevented some users from performing a proper assessment. The scores of the tool are shown below:

Table 13 Score by heuristic principle of AR (Mobile App Client) (mid-term)

1. Visibility of system status	68,00	IMPROVE
2. Match between system and the real world	86,67	PASSED
3. User control and freedom	45,00	FAILED
4. Consistency and standards	80,00	PASSED
5. Error prevention	16,67	FAILED
6. Recognition rather than recall	50,00	IMPROVE
7. Flexibility and efficiency of use	48,33	FAILED
8. Aesthetic and minimalist design	70,00	IMPROVE
9. Help users recognize, diagnose, and recover from errors	11,11	FAILED
10. Help and documentation	6,67	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

1. Visibility of system status

Users can check if they are logged in or out but cannot watch any status message indicating that the system is processing a new command, as well as any information about the user profile. Users miss more feedback in this regard. No login button is available.

3. User control and freedom

It is not possible to redo a colour change, but just to choose a different one. Also, there is no exit or log out button. It is not possible to leave the chat so, once this is opened, this remains indefinitely on the screen. Positive actions (e.g., 'add' or 'yes') could always be on the right button, so they appear on the left side which gives an unnatural feeling. Users also consider, to provide an easier working mechanism, to make a clear distinction between the exit button and the menu option (colour, material, etc.) so, in the configuration section, it is quite easy to confuse the 'up arrow' with the exit button located on the bottom. The system also lacks a 'home' icon and users must use the 'exit'/'go back' options every time, and these are not located on the same side of the page.

5. Error prevention

When a new product is added, users do not know where to find it later. They eventually found it in the configurator. It would be more natural to have it available in a portfolio or the Team products.

6. Recognition rather than recall

User could not find any help, and there is no search option available.

7. Flexibility and efficiency of use

The save effort can be assumed but then it is quite difficult to reopen it correctly. Furthermore, the contact tab is empty and there is no information available. Some buttons are also empty (e.g., the headboard) and some icons seem to have no utility.

8. Aesthetic and minimalist design

Users consider that the home page could be somehow improved.

9. Help users recognize, diagnose, and recover from errors

Some detected errors trigger notifications to the users, but others do not. As an example, on the left side there is an empty button once the headboard is selected. The notification messages are not centred in the frame, and the users are only able to watch the bottom half of the prompted sentences. As a good point, the text of the detected error is usually understandable.

10. Help and documentation

There is no help documentation available in the tool.

3.5.2. Final Evaluation

The overall score of this tool has been 61,32, with the involvement of 8 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 14 Score by heuristic principle of AR (Mobile App Client) (final)

1. Visibility of system status	82,50	PASSED
2. Match between system and the real world	75,00	PASSED
3. User control and freedom	59,38	IMPROVE
4. Consistency and standards	87,50	PASSED
5. Error prevention	48,21	FAILED
6. Recognition rather than recall	53,13	IMPROVE
7. Flexibility and efficiency of use	51,19	IMPROVE
8. Aesthetic and minimalist design	81,25	PASSED
9. Help users recognize, diagnose, and recover from errors	50,00	IMPROVE
10. Help and documentation	25,00	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

Some users could not find the logout, and no update of product was made without exiting and reopening the app. The option to return Home is available, but only through the 'exit' button, which is available in the menu, when entering in the product edition mode.

5. Error prevention

Users do not know how to move or perform actions in the app. The addition to products is confusing and it is not possible to know if a product has a suitable 3D model associated. It is difficult to navigate through the app, and when the user is in edition mode, the actions available are not fully clear.

6. Recognition rather than recall

There is no context help, which makes the navigation a kind of trial and error. The tool lacks information to offer a better navigation experience and usage of the tool. Also, there is no search option that could be useful to navigate through the list of products.

7. Flexibility and efficiency of use

The contact tab is not working, no information is present. The settings option also has no content, and the annotations do not work properly.

9. Help users recognize, diagnose, and recover from errors

It would be nice to understand if a 3D model associated with a product is available and can be processed by the tool. When pressing some buttons (i.e.: materials, colours) nothing occurs, and the tool does not display any message.

10. Help and documentation

Users could not find any documentation.

3.5.3. Improvements achieved

With the latest updates, the materials can be mapped from the Marketplace, and they can be changed from the options of the product. Besides this, several bugs have been fixed.

3.6. VR (VR Client)

3.6.1. Midterm Evaluation

The overall score of this tool has been 50,33, with the involvement of 6 evaluators. In this case it should be noted that the low number of evaluators was due to problems with the response time of the tool in many computers. This prevented some users from doing an adequate evaluation of the tool. The scores of the tool based on the heuristic principles can be inspected below:

Table 15 Score by heuristic principle of VR Client (mid-term)

1. Visibility of system status	53,33	IMPROVE
2. Match between system and the real world	88,89	PASSED
3. User control and freedom	50,00	IMPROVE
4. Consistency and standards	66,67	IMPROVE
5. Error prevention	25,00	FAILED
6. Recognition rather than recall	58,33	IMPROVE
7. Flexibility and efficiency of use	58,33	IMPROVE
8. Aesthetic and minimalist design	75,00	PASSED
9. Help users recognize, diagnose, and recover from errors	22,22	FAILED
10. Help and documentation	5,56	FAILED

Below, the most relevant comments from users can be found, focusing on the heuristic principles that were failing or can be significantly improved:

1. Visibility of system status

The users can check if they are logged in or not and cannot watch some status indicating that the system is doing some tasks, or information about the user profile. There is no login button. Once the users log-in, they are not sure about being properly connected with the tool working, so a white screen appears due to an over-zoomed phenomenon. Regarding interactions, only the model loading takes some time, but this is considered acceptable. Besides this, there is no feedback from the system to the users. The status messages partially appear on the screen. As an example, when adding a new product, the confirmation message appears on the very top of the screen, and it is not possible to read

it properly. The top menu is not well positioned in the frame and the users cannot read (e.g., the notifications when a new action is implemented). The display is not well-adapted to most screen sizes (users need to zoom at 50%) so different areas are not easy to find at first. When the users are not located in the main menus (e.g., products, settings), they do not know in which area they are located (the URL remains the same). The users cannot go back in main menus (usually Alt + </-) except by using the exit button.

3. User control and freedom

There are no undo/redo actions available. Some users could not check this principle properly because they could not create a product. The system usually offers an emergency exit option at any area, but it is not possible to leave the chat so, once this is open, this remains always on the screen. Other users detected that this cannot be closed if the configurator page is closed. The 'positive' actions such as 'add' could always be on the right side, so now it is placed on the left part, and this can be considered not so intuitive. The overall working of the tool could be easier. It is quite easy for users to make mistakes when using the exit button (which is placed on the bottom) in the configurator page. It would be recommended to put the exit button apart from the menu option (e.g., colour, material, etc.) placing it on the top. There is no home icon and link. The 'exit'/'go back' options have to be used quite often, and they are not located on the same side of the page.

4. Consistency and standards

The users do not find the visual elements of the selected products in the configurator section. The scrolling is very slow (e.g., in the products menu) which is quite unusual.

5. Error prevention

The new added products cannot be found later by the users. They eventually found them available in the configurator, but it would be more intuitive to have them available in the portfolio or team's products. The users miss more information.

6. Recognition rather than recall

No help was found. The chat does not seem to work and there is no search option.

7. Flexibility and efficiency of use

The save effort is possible but it is difficult to reopen correctly. It takes a very long time to load the VR client after login. Most loadings (e.g., initial log in, "my designs" area) are quite slow. In addition, the contact tab is empty, and no contact or information is available. There are some empty buttons (e.g., headboard) and some icons seem to have no function.

9. Help users recognize, diagnose, and recover from errors

Some detected errors trigger notifications, but some do not (e.g., on the left side, there is one empty button when the user selects the headboard). The notification messages are not centred in the frame, and the users can only read the bottom half of the sentences.

10. Help and documentation

No help button is available for extra guidance documentation.

3.6.2. Final Evaluation

The overall score of this tool has been 54,70, with the involvement of 12 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 16 Score by heuristic principle of VR Client (final)

1. Visibility of system status	**70,00**	**IMPROVE**
2. Match between system and the real world	**69,44**	**IMPROVE**
3. User control and freedom	**62,50**	**IMPROVE**
4. Consistency and standards	**79,17**	**PASSED**
5. Error prevention	**35,23**	**FAILED**
6. Recognition rather than recall	**43,75**	**FAILED**
7. Flexibility and efficiency of use	**61,87**	**IMPROVE**
8. Aesthetic and minimalist design	**83,33**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**33,33**	**FAILED**
10. Help and documentation	**8,33**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

1. Visibility of system status

For some users the switch between tabs is fast, but the loading time is too long (at least 5 min. to load the tool on the computer), and the loading of products also takes a long time. Moreover, the user has to go back to the platform if makes a mistake regarding the size of the 3D product, and there is no link to the iPRODUCE page. Some users were not able to find the logout option. However other users consider that the system status is visible in the top left corner.

2. Match between system and the real world

The system becomes quite hard to understand. Although the language is understandable, there is no explanation on what a product is, what a design is, and how a design can become a product and vice-versa. Some words seem to be interchangeable to some extent, which makes the tool confusing. The Home icon links to products, when for some users it should link to a different landing page. Also, the contact and settings tabs are empty and therefore useless,

3. User control and freedom

If the user makes mistakes, it is quite difficult to fix them, so must go back to the whole process. There was no logout and no product update without exiting and re-entering the app. Some users detected keyboard shortcuts for the 'undo' and 'redo' actions, but no buttons available for that. The option to return Home is available just through the 'exit' button.

5. Error prevention

While moving the 3D product, sometimes the product disappears from the screen, and it is not possible to retrieve it. There is no information on how to avoid this. Some interactions are a bit confusing and even when making a mistake, it is not clear how to undo it (i.e.: annotations). Also as commented earlier, information about how to perform actions is missing, and it is not possible to understand if a product has associated a 3D model suitable for the tool, quite hard to navigate through the app, and once inside the product edition mode, the different actions available are not clear enough.

6. Recognition rather than recall

There are no elements indicating the difference of a design and a product and how they are related. The same applies to the configurator. The meaning of the icons is not clear and, even if the user can

find out about its functionality, this is not obvious from the beginning. No context help and search are available, and more information would be useful to provide a better navigation experience.

7. Flexibility and efficiency of use

In the 3D visualisation there are a few shortcuts for scale, rotate and move. However, users could not get them to work. No personalisation option was identified while navigating. Moreover, the loading of the app takes quite long, more than 5 min. and the loading of products is also slow. A contact button exists but no information is present.

9. Help users recognize, diagnose, and recover from errors

As commented earlier, it would be nice to know if a 3D model associated with a product is available and can be processed by the tool. Also, when moving from the marketplace to the VR for the wood bike, some users got an error message which was not easy to understand. In general, no information about errors is displayed.

10. Help and documentation

No documentation was found.

3.6.3. Improvements achieved

3D environment was added. In this environment the users can display more than one product and modify the products to create a composition. As in the AR tool, the materials were mapped from the Marketplace and they can be changed from the options of the product, and different bugs were solved.

3.7. Mobile App for Social Media

3.7.1. Midterm Evaluation

The overall score of this tool has been 66,56, with the involvement of 6 evaluators. The reason under the low number of evaluators of this tool was the need for a smartphone device and the problems often found when creating surveys. The scores of the tool are indicated here:

Table 17 Score by heuristic principle of Mobile App for Social Media (mid-term)

1. Visibility of system status	83,33	PASSED
2. Match between system and the real world	66,67	IMPROVE
3. User control and freedom	81,67	PASSED
4. Consistency and standards	90,00	PASSED
5. Error prevention	50,00	IMPROVE
6. Recognition rather than recall	75,00	PASSED
7. Flexibility and efficiency of use	63,89	IMPROVE
8. Aesthetic and minimalist design	83,33	PASSED
9. Help users recognize, diagnose, and recover from errors	49,44	FAILED
10. Help and documentation	22,22	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

2. Match between system and the real world

Some sections do not contain a look of natural language to users. In the user dashboard of the marketplace tool, there is an icon/button informing the user to publish the product on the main page, but this does not appear here. The user icon does not make much sense to users because they cannot select any picture or a different image.

5. Error prevention

A loading circle appears on the screen when there is no questionnaire. When a questionnaire is done in the marketplace there is no indication about its status indicating that this cannot be done again. Using different user profiles the results vary, so some profiles can access some questionnaires while others cannot, with the criteria being unclear. Besides this, user mistakes such as wrong password or existing usernames are properly indicated.

7. Flexibility and efficiency of use

The front page contains a set of dots "…" that seem to be an option to expand the text area so the users can continue reading the created content. However, this does not work.

9. Help users recognize, diagnose, and recover from errors

If there is no questionnaire, a loading circle appears all the time and the users may guess that the tool is not working. There is not enough support information.

10. Help and documentation

Users miss some help documentation.

3.7.2. Final Evaluation

The overall score of this tool has been 74,97 – which could be almost considered as a final PASSED rating - with the involvement of 8 evaluators. The scores of the tool are shown below:

Table 18 Score by heuristic principle of Mobile App for Social Media (final)

1. Visibility of system status	**95,00**	**PASSED**
2. Match between system and the real world	**87,50**	**PASSED**
3. User control and freedom	**65,63**	**IMPROVE**
4. Consistency and standards	**92,86**	**PASSED**
5. Error prevention	**69,05**	**IMPROVE**
6. Recognition rather than recall	**65,63**	**IMPROVE**
7. Flexibility and efficiency of use	**72,62**	**IMPROVE**
8. Aesthetic and minimalist design	**100,00**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**72,22**	**IMPROVE**
10. Help and documentation	**29,17**	**FAILED**

Most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

3. User control and freedom

For some users to understand how the tool works took a while, so there were more than one questionnaire and could not switch between them. Also, no Home option was present.

5. Error prevention

Instructions on how to perform the actions could be improved. When a survey is started, and the user goes back to Home, the replies are cleared.

6. Recognition rather than recall

If the user has more than one survey just a list is shown, and there is no search option available.

7. Flexibility and efficiency of use

The contact information is empty, and no customisation options are available.

9. Help users recognize, diagnose, and recover from errors

When a product is not added because of some error, users do not know that the FBX file is missing. This also applies when there are some problems with the product.

10. Help and documentation

No documentation was available.

3.7.3. Improvements achieved

A version of the app for IOS was created. The colours of the UI were fixed, and in the latest version the results of the survey can be saved and displayed in the Agile data Analytics tool. Besides this, several bugs were also solved.

3.8. Agile Data Analytics and Visualization Suite

3.8.1. Midterm Evaluation

This tool was not able to be properly evaluated in the first evaluation round.

3.8.2. Final Evaluation

This tool scores overall 72,34, with the involvement of 8 evaluators. Scores shown below:

Table 19 Score by heuristic principle of Agile Data Analytics & Visualization Suite (final)

1. Visibility of system status	75,00	PASSED
2. Match between system and the real world	95,83	PASSED
3. User control and freedom	64,29	IMPROVE
4. Consistency and standards	75,00	PASSED
5. Error prevention	60,71	IMPROVE
6. Recognition rather than recall	71,88	IMPROVE
7. Flexibility and efficiency of use	68,75	IMPROVE
8. Aesthetic and minimalist design	100,00	PASSED
9. Help users recognize, diagnose, and recover from errors	50,00	IMPROVE
10. Help and documentation	61,90	IMPROVE

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

User could not find an 'exit' option and the option 'My Survey' sometimes appeared hidden.

5. Error prevention

When there is no data, and all the graphics are empty no feedback is presented to the user. Regarding the indications about how to perform actions in the tool, this mainly applies when exploring graphs. A hidden menu is there where contextual information is presented.

6. Recognition rather than recall

Regarding context help, just information to all sections and not separated according to the section is presented to the user. The issue previously commented about graphs also applies here. Moreover, no search option was found while navigating.

7. Flexibility and efficiency of use

For some users, the tool includes contextual menus, drop downs, and enough visualisation options   . The personalisation is based on the selections made by the users. The response time is usually slow, but acceptable for the use of real-time data. Loading time at the start takes quite long, but once running, interactions are smoother and faster. Therefore, the system provides an acceptable response time. Only in the user profile there is some information, but no contact information was found.

9. Help users recognize, diagnose, and recover from errors

When some error occurs, no data or information is prompted.

10. Help and documentation

Some information is provided but from the users' perspective this cannot be considered documentation nor guidelines, just general information.

3.8.3. Improvements achieved

A new frontend was implemented and improved the connection with the Marketplace database. Also added the number of users, teams, products additional information on each tab. The location of the registered users was also added, as well as the results of the survey. The overall performance of the tool was improved, and several bugs found were fixed.

3.9. Video Intelligence

3.9.1. Midterm Evaluation

The overall score of this tool has been 60,07, with the involvement of 9 evaluators. The scores of the tool based on the heuristic principles are indicated below:

Table 20 Score by heuristic principle of Video Intelligence (mid-term)

1. Visibility of system status	71,11	IMPROVE
2. Match between system and the real world	66,67	IMPROVE
3. User control and freedom	61,11	IMPROVE
4. Consistency and standards	75,00	PASSED

5. Error prevention	**50,00**	**IMPROVE**
6. Recognition rather than recall	**66,67**	**IMPROVE**
7. Flexibility and efficiency of use	**53,01**	**IMPROVE**
8. Aesthetic and minimalist design	**88,89**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**57,14**	**IMPROVE**
10. Help and documentation	**11,11**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

1. Visibility of system status

After clicking on a video (entering a specific video), no information about the video appears, and there is no change of cursor pointer when moving the mouse over the videos. The users cannot find the repository that contains all the videos available, and they need to upload a video to edit a previous one. Furthermore, there is no indication for the user to be aware if logged in or out. When the users are in the upload video section, the tab of videos is not showing that the user is in such a section.

2. Match between system and the real world

The arrows, search, cross, and circle buttons are not working, and it is not clear to the users what they are for. The icon in the top right corner is not understandable. Indeed, the "Watch video" icon allows you to run a video, but it is not the actual video figuring next to the button. The video uploaded by the user appears on the bottom of the page, and next to it a "watch video" button appears, independently from where the user clicks. In short, the organisation of the information displayed in the system is quite confusing.

3. User control and freedom

A user uploaded the same video three times but could not delete those that were considered unnecessary. The only undo/redo option available is the web browser one. Sometimes users could not upload a video for testing. Users need to upload a video first to then be able to access the video area again and edit or delete the previous video. The interaction level with the system is considered quite low.

5. Error prevention

Sometimes the error message "Failure - Could not upload the file. Please, refresh the page and try again" appears when trying to upload a video. Users can upload videos without introducing title or information, and there is no uploading estimation time or loading bar to inform the user about the status, which may lead to an error if the user tries to save at that time.

6. Recognition rather than recall

The only illustrative elements are the up and down arrows and the recording icon on the top right corner. However, it is not clear what their functions are. The arrows and circle icons are confusing and there is not enough information about the meaning of the buttons. The search option is easy to find but does not work.

7. Flexibility and efficiency of use

As commented earlier by the users, the buttons and the search area are available, but they do not work. There are no customisation options, and the "Transcribe and Object detection" option may take several minutes. No contact information is available (or at least could not be found) to ask for support

and submit questions. The links in the system seem to work fine, but the test videos that appear in the UI have broken links.

9. Help users recognize, diagnose, and recover from errors

It was not possible to fully assess this heuristic parameter without being able to move past the upload page, so just the upload error could be considered in the evaluation. When clicking on a specific video, sometimes another video is shown. Regarding errors, some information is prompted to the user when they occur, but the indicated solution does not solve the problem (i.e.: file upload). However, when the users try to upload a wrong file format, the system properly notifies this error.

10. Help and documentation

There is no help button for documentation and guidelines.

3.9.2. Final Evaluation

The overall score of this tool has been 66,49, with the involvement of 8 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 21 Score by heuristic principle of Video Intelligence (final)

1. Visibility of system status	77,50	PASSED
2. Match between system and the real world	83,33	PASSED
3. User control and freedom	69,64	IMPROVE
4. Consistency and standards	75,00	PASSED
5. Error prevention	75,00	PASSED
6. Recognition rather than recall	65,63	IMPROVE
7. Flexibility and efficiency of use	56,25	IMPROVE
8. Aesthetic and minimalist design	87,50	PASSED
9. Help users recognize, diagnose, and recover from errors	50,00	IMPROVE
10. Help and documentation	25,00	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

3. User control and freedom

Some users could not stop the recording, and the only way to undo an action is by using the actions from the browser, and no 'exit' option was found. However, the navigation results are clear, so the interface is quite simple and the Home option is easy to find.

6. Recognition rather than recall

As this tool is mainly a video-oriented application, the usual video controls and actions are provided, but no help options were identified. There is no indication of the types of files (extensions) that can be uploaded into the platform, so some additional context information could be useful. Furthermore, the search option is available, but sometimes does not work as expected and the users consider that the search seems to look for exact terms only instead of looking for partial matches.

7. Flexibility and efficiency of use

No personalisation option was seen by the users. Sometimes the search did not retrieve any result and the buttons did not work.

9. Help users recognize, diagnose, and recover from errors

For some users, when trying to upload an MP4 video, the upload did not work and there was no error message about the error or explaining how to fix it.

10. Help and documentation

No help nor documentation was available.

3.9.3. Improvements achieved

In the latest version, a new navigation tab was added, and the users can directly access the uploaded videos and edit them without doing all the process to upload a video. Furthermore, a search bar has been added.

3.10. CMDF Training Flow

3.10.1. Midterm Evaluation

The overall score of this tool has been 62,22, with the involvement of 4 evaluators. The low number of evaluators was due to the installation process of the tool, that became a bit tricky for some users. The scores of the tool based on the heuristic principles can be inspected below:

Table 22 Score by heuristic principle of CMDF Training Flow (mid-term)

1. Visibility of system status	75,00	PASSED
2. Match between system and the real world	66,67	IMPROVE
3. User control and freedom	79,17	PASSED
4. Consistency and standards	87,50	PASSED
5. Error prevention	37,50	FAILED
6. Recognition rather than recall	75,00	PASSED
7. Flexibility and efficiency of use	59,72	IMPROVE
8. Aesthetic and minimalist design	100,00	PASSED
9. Help users recognize, diagnose, and recover from errors	41,67	FAILED
10. Help and documentation	0,00	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

2. Match between system and the real world

Users consider that the language could be more natural. Also, further clarifications could be included if the language is too technical. The organisation of the information displayed sometimes does not make much sense (e.g., when adding resources).

5. Error prevention

Some notifications are missing, and sometimes the system crashes after the prompting of an error. Some warnings do not contain any explanation to support the user on how to proceed. It is not easy

for users to create a flow/training (e.g., do they need to add the resources first? what is an operative? how the resources can be organised? and the relationships between them established?).

7. Flexibility and efficiency of use

Users are forced to navigate through different tabs to watch elements that will supposedly be used in the connection with each other, which is considered by them as too time consuming. Users also miss the option to drag and drop resources, which seems to not be implemented. Besides this, when adding equipment in the inventory tab, the users could not add any resource to it so, when the resource is selected, there is no button to perform such addition. Furthermore, the system crashes from time to time.

9. Help users recognize, diagnose, and recover from errors

The system does not prompt any message when this crashes, and there is not much information about the errors. When warnings are prompted in the tool, there is no information about the cause or how to proceed.

10. Help and documentation

There is no documentation available for the users.

3.10.2.   Final Evaluation

The overall score of this tool has been 70,57, with the involvement of 5 evaluators. The scores of the tool based on the heuristic´s principles are shown below:

Table 23 Score by heuristic principle of CMDF Training Flow (final)

1. Visibility of system status	84,00	PASSED
2. Match between system and the real world	73,33	IMPROVE
3. User control and freedom	80,00	PASSED
4. Consistency and standards	90,00	PASSED
5. Error prevention	80,00	PASSED
6. Recognition rather than recall	75,00	PASSED
7. Flexibility and efficiency of use	80,00	PASSED
8. Aesthetic and minimalist design	70,00	IMPROVE
9. Help users recognize, diagnose, and recover from errors	66,67	IMPROVE
10. Help and documentation	6,67	FAILED

Most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

2. Match between system and the real world

Sometimes for the users it is hard to determine if the organisation of the information displayed makes sense.

8. Aesthetic and minimalist design

There are no comments about this parameter, but the evaluation indicates that this aspect needs to be improved.

9. Help users recognize, diagnose, and recover from errors

This aspect seems to be addressed, but if the user wants to save an element, the system still asks to provide a name, and it is not possible to leave without providing such a name.

10. Help and documentation

Although no comments have been provided by the users, the evaluation indicates that there is not documentation nor help available.

3.10.3.　　Improvements achieved

No significant improvements between the first and final rounds period were found.

3.11. CMDF Training View

3.11.1.　　Midterm Evaluation

The overall score of this tool has been 59,57, with the involvement of 5 evaluators. The reason under this low number of evaluators was the need for compatible smartphone device and the installation of the application file, what prevented some users from performing the evaluation of this tool. The scores of the tool based on the heuristic´s principles are indicated below:

Table 24 Score by heuristic principle of CMDF Training View (mid-term)

1. Visibility of system status	**64,00**	**IMPROVE**
2. Match between system and the real world	**93,33**	**PASSED**
3. User control and freedom	**70,00**	**IMPROVE**
4. Consistency and standards	**100,00**	**PASSED**
5. Error prevention	**35,00**	**FAILED**
6. Recognition rather than recall	**75,00**	**PASSED**
7. Flexibility and efficiency of use	**33,33**	**FAILED**
8. Aesthetic and minimalist design	**100,00**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**25,00**	**FAILED**
10. Help and documentation	**0,00**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

1. Visibility of system status

Although the appearance of the options of the application can be considered as an indication to the users about being logged in or not, it is recommended to have a clear indication about this. There is also no indication about in which section of the tool from those of the menu option is the user located in each time (e.g., tools, landscape, etc.). When the users exit or finish the process, the application freezes. Also, some issues when downloading a procedure were found, although the overall feeling in this regard is positive. Users sometimes cannot access it after clicking on the start option.

3. User control and freedom

The system apparently lacks some undo/redo options. Besides this, some users could not go deep into the creation of products here, so there might be pages that they were not able to test. Some users need to click three times on the exit option to leave the tool and in some cases, this was not possible.

5. Error prevention

There is no error information display. The users miss more indications explaining how the tool works.

7. Flexibility and efficiency of use

There are no personalisation options available. Also, the exit takes quite long, and the users detected several bugs when testing. In most cases the application did not launch. The digital twins option redirects to the GitHub, and there are menu options that are not working. Indeed, only the 'tools and 'landscape' functions work.

9. Help users recognize, diagnose, and recover from errors

Sometimes the screen remains endlessly loading, and users did not get any error messages or information about how to solve the problem.

10. Help and documentation

There is no documentation available in the tool.

3.11.2.   Final Evaluation

The overall score of this tool has been 64,67, with the involvement of 5 evaluators. The scores of the tool based on the heuristic principles are shown below:

Table 25 Score by heuristic principle of CMDF Training View (final)

1. Visibility of system status	**80,00**	**PASSED**
2. Match between system and the real world	**93,33**	**PASSED**
3. User control and freedom	**85,00**	**PASSED**
4. Consistency and standards	**80,00**	**PASSED**
5. Error prevention	**50,00**	**IMPROVE**
6. Recognition rather than recall	**80,00**	**PASSED**
7. Flexibility and efficiency of use	**50,00**	**IMPROVE**
8. Aesthetic and minimalist design	**80,00**	**PASSED**
9. Help users recognize, diagnose, and recover from errors	**41,67**	**FAILED**
10. Help and documentation	**6,67**	**FAILED**

The most relevant comments from users can be found below, focusing on the heuristic principles that fail or present room for improvement:

5. Error prevention

Some users did not experience any error but did not find information about the configuration. In some cases, after having selected a 'Procedure', if the user selects the arrow on the right side, a message indicating 'Procedure Finished' is prompted, even if the user did not do anything. The system should warn the user that nothing was done yet. Furthermore, after opening the app, two options appear:

'Start' or 'Configure'. There is no complementary information about what the app is and what it is expected to do. It is not clear what can be configured and its implications.

7. Flexibility and efficiency of use

Some users could not create their own procedures, and no customization options were found. Moreover, some problems regarding the loading were detected. For instance, from a set of four procedures, two of them opened quickly, the third one was slow, and the fourth one was stuck on 'loading'. No contact information was identified, but no broken links were found.

9. Help users recognize, diagnose, and recover from errors

The errors related to the loading problems did not retrieve any feedback.

10. Help and documentation

Some documentation is available by selecting the 'Digital Twin' button in the main menu. However, this redirects the user to GitHub. It is not clear that this is for immediate help. Also, some documentation was found a bit hidden through the 'Digital Twin' button, and this should be called 'Digital FabLab Kit' instead.

3.11.3.   Improvements achieved

No significant improvements between the first and final rounds period were found.

3.12. Process Automation Tool

This tool has been experimented only by AIDIMME in the scope of the ES-cMDF.

3.12.1.   Midterm Evaluation

The overall score of this tool has been 62,17, with only the involvement of AIDIMME as evaluator. The scores of the tool based on the heuristic principles are shown below:

Table 26 Score by heuristic principle of Process Automation Tool (mid-term)

1. Visibility of system status	80,00	PASSED
2. Match between system and the real world	100,00	PASSED
3. User control and freedom	75,00	PASSED
4. Consistency and standards	100,00	PASSED
5. Error prevention	50,00	IMPROVE
6. Recognition rather than recall	50,00	IMPROVE
7. Flexibility and efficiency of use	66,67	IMPROVE
8. Aesthetic and minimalist design	100,00	PASSED
9. Help users recognize, diagnose, and recover from errors	0,00	FAILED
10. Help and documentation	0,00	FAILED

The most relevant comments from users can be found below, focusing on the heuristic principles that failed or presented room for improvement:

5. Error prevention

The users consider that the overall usage of the application is not difficult, but some short information would be valuable.

6. Recognition rather than recall

Together with the point commented above, there is no search, although maybe this could not be required. This could be evaluated.

7. Flexibility and efficiency of use

The users detected some performance issues, so sometimes the application blocks. Furthermore, there is no contact information available in the tool.

9. Help users recognize, diagnose, and recover from errors

No exceptions were prompted, as well as support information and the process could not be successfully finished.

10. Help and documentation

There is no documentation and help available.

3.12.2.   Final Evaluation

At the time of this writing, the new version of the Process Automation Tool, which is expected to include some improvements, was not available to perform the heuristic evaluation.

3.12.3.   Improvements achieved

Considering that this tool was not able to be properly evaluated in the final round of the evaluation, no improvements could be found. However, important improvements have been made in the Process Automation Tool. The greatest advances that have been made are related to the way of validating the changes made by each actor regarding the specifications in the Design Brief, since each change involved cycles of review and acceptance by everyone. This process has been streamlined considerably. In addition, the functionality of generating a report of all the activities carried out has been added, as well as including the CAD file. The way of contemplating times has been improved so that no delays occur in task´s planning with proper management. Besides this, the frontend was changed, as well as the logic, and different types of tiles can be attached.

4. Validation through KPIs

The KPIs defined for each cMDF can be found in deliverable D2.5 Definition of iPRODUCE Demonstration Framework [6], under the 'IPRODUCE Use Cases Definition' chapter, where they are described and can be put in the context of the corresponding use cases.

4.1. Spanish cMDF

4.1.1. Preliminary Tests and OpIS Technologies Involved

The Marketplace, matchmaking, AR, and VR tools, the IPR and the Mobile App for social media are those tools which have most impacted on the KPI values achieved during the evaluation of the OpIS platform. They impact on the number of proposals and ideas for new product design, the time dedicated to the search of partners and the production of first prototypes, the involvement of actors and the gathering of opinions. This has improved the satisfaction of both makers and users. In this last aspect, the Agile Analytics tool has played an important role. Besides this, the Process Automation Tool, which has been exclusively adopted by the Spanish cMDF, has improved the time for the collaborative management of the prototype production and for the decision-making, as well as improved the overall activities related to the product innovation and the co-creation activities.

4.1.2. Midterm Evaluation

It should be noted that many KPI values could not be obtained at M29, so they were not applicable at that time through the OpIS platform.

Table 27 KPI-based validation results of the Spanish cMDF at mid-term (M29)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value MID-TERM (M29)	TO-BE value	STATUS
Intelligent Headboard	Number of proposals for the conceptual design based on the initial idea	1 proposal	2	> 3 proposals	-
	Reduction of the time spent searching for the right partner	≈ 15 days	-	< 2 days	-
	Number of actors in the co-design phase	2 actors (Designer and Manufacturer)	3 (LAG, AID, ON)	> 2 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	12 opinions at most that are part of a small focus group.	6	> 30 opinions	-

	Improve the time for the collaborative management of complete prototype process	70 days with manual work: excel emails, etc	-	≈ 30 days	-
	Time between the manufacturer first contact and the final prototype production	90 days Contact with designers, planning, final production	80	< 60 days	-
Smart adjustable gamer chair	Number of proposals for the conceptual design based on the initial idea	1 proposal	4	> 3 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days	-	< 2 days	-
	Number of actors in the co-design phase	1 actor (gamer)	3 (LAG, AID, ON) Gamers outside OpIS	> 2 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	3 opinions	6	> 30 opinions	-
	Time between the gamer first contact and the final prototype planning	90 days	-	< 60 days	-
	Increase the number of ideas for new furniture product design addressing young people (target)	1 idea	-	> 3 ideas	-
	Improve product innovation and co-creation activities	Design Thinking activity	-	≈ 20% more improvement over the initial value	-
	Improve user satisfaction	Questionnaire score	0	> 50% on user satisfaction over the original score	-
3D printed components for assembling customized furniture	Improvement of the time in the decision-making process	≈ 15 days	10 days	> 20% improvement	-
	Improvement of product innovation and co-creation activities	Creative and Innovation Management	-	> 30% improvement	-

		activity			
	Reduction of the time spent searching for the right partner to develop the prototype	≈ 15 days	-	< 2 days	-
	Improve makers' and users' satisfaction	Questionnaire score	-	> 50% on user satisfaction over the original score	-
	Number of makers proposals based on the initial idea	1 proposal	-	> 3 proposals	-
	Reduction of the time for the final prototype planning	90 days	-	< 60 days	-

4.1.3. Final Evaluation

Table 28 KPI-based validation results of the Spanish cMDF at final round (M39)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value FINAL (M39)	TO-BE value	STATUS
Intelligent Headboard	Number of proposals for the conceptual design based on the initial idea	1 proposal	4	> 3 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2 actors (Designer and Manufacturer)	6 (LAG, AID, ON) + Core Group	> 2 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	12 opinions at most that are part of a small focus group.	50 (EASD, Core Group, AIDIMME staff)	> 30 opinions	ACHIEVED
	Improve the time for the collaborative management of complete prototype process	70 days with manual work: excel emails, etc	28	≈ 30 days	ACHIEVED

	Time between the manufacturer first contact and the final prototype production	90 days Contact with designers, planning, final production	30	< 60 days	ACHIEVED
Smart adjustable gamer chair	Number of proposals for the conceptual design based on the initial idea	1 proposal	4	> 3 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	1 actor (gamer)	16 (gamers + AID + ON)	> 2 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	3 opinions	40 (Gamers, Core Group, AIDIMME staff)	> 30 opinions	ACHIEVED
	Time between the gamer first contact and the final prototype planning	90 days	30	< 60 days	ACHIEVED
	Increase the number of ideas for new furniture product design addressing young people (target)	1 idea	6	> 3 ideas	ACHIEVED
	Improve product innovation and co-creation activities	Design Thinking activity	40%	≈ 20% more improvement over the initial value	ACHIEVED
	Improve user satisfaction	Questionnaire score	70%	> 50% on user satisfaction over the original score	ACHIEVED
3D printed components for assembling customized furniture	Improvement of the time in the decision-making process	≈ 15 days	50%	> 20% improvement	ACHIEVED
	Improvement of product innovation and co-creation activities	Creative and Innovation Management activity	50%	> 30% improvement	ACHIEVED
	Reduction of the time spent searching for the right partner to develop the prototype	≈ 15 days	1	< 2 days	ACHIEVED
	Improve makers and users satisfaction	Questionnaire score	70%	> 50% on user satisfaction	ACHIEVED

				over the original score	
Number of makers proposals based on the initial idea	1 proposal	4	> 3 proposals	ACHIEVED
Reduction of the time for the final prototype planning	90 days	20	< 60 days	ACHIEVED

4.1.4. Impact Assessment

When evaluating the KPIs defined at the beginning of the project with the values currently obtained towards the end of the project) from each UC, it can be concluded for:

Use Case 1 – Intelligent Headboard: 4 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 2 physical prototypes were produced and presented in different Fairs.

Use Case 2 – Smart adjustable gamer chair: 4 different designs were made based in the feedback provided by real gamers (more than 10), as well external people using gamer chairs and the Core group members (total 40 opinions) adapting the desired specifications (based on interviews) and keeping the usual design esthetics in a real gamer chair.

Use Case 3 – 3D printed components for assembling customised furniture: 4 different designs for creating a geodesic dome were done. The time reduction can be highlighted by collaborating in the way of doing it thanks to the activity through the OpIS platform. Part of the dome was made for the Fair; around 30 3D printed parts were produced for creating the dome.

4.2. German cMDF

4.2.1. Preliminary Tests and OpIS Technologies Involved

While the Marketplace increases the options to advertise services to a broad audience, the Matchmaking helps companies to find services for their needs. This impacts the number of people taking part in the projects initiated in the use case, the addressing of more consumer goods sectors and customer-driven products, the consultation to startups, and the involvement of makers and consumers in the co-design of products. Besides this, the Training Support Tool has facilitated the creation and use of digitised material, increasing the quantity and the completion of sample projects by makers using tools that they did not use before. The Matchmaking together with the Agile Network Creation Tool enables the definition of business models, in this case for demand-driven economy business models. The application of collective intelligence principles for co-design has been improved by the Generative Design Platform, which can host and manage more proposals. Finally, the proposed Guided Product Development as a Service reduces the cost for new products.

4.2.2. Midterm Evaluation

Table 29 KPI-based validation results of the German cMDF at mid-term (M29)

UC#	KPI	AS-IS value BEFORE	AS-IS value MID-TERM (M29)	TO-BE value	STATUS
1: Co-Creation Introduction for SMEs	Participants in the pilot activities	8	115	100	-
	Consumer goods sectors addressed	0	3	1	ACHIEVED
	Customer-driven products manufactured in cMDFs	0	2	2	ACHIEVED
	Community members as beneficiaries of co-creation training	0	80	50	
2: Machinery Training	Amount of digitized training material	Not yet collected	3	5% higher than AS-IS value	-
	Number of available virtual workshops	Not yet collected	2	5	-
	Digital Fablab Kit	0	1	1	ACHIEVED
	Makers who complete sample projects with material, machinery, or tools they have not used before	0	13	10	-
3: Guided Product Development as a Service	Demand-driven sharing economy business models	0	1	1	ACHIEVED
	Number of startups consulted	0	17	20	-

	Improved time to market of products	TBD through web search	4-8W	Lower than AS-IS value	-
	Makers and consumers involved in the co-design of products	0	95	20	ACHIEVED
	Startups' perceived ability to apply collective intelligence principles for the co-design on new products	0	9	20% higher than AS-IS value	-
	Development costs for new products	TBD through web search	250k	Lower than AS-IS value	-
4: IoT Kit	Consumer goods sectors addressed	0	4	3	ACHIEVED
	Customer-driven products manufactured in cMDFs	0	2	2	ACHIEVED
	Validated, market ready products	0	2	1	ACHIEVED

4.2.3. Final Evaluation

Table 30 KPI-based validation results of the German cMDF at final round (M39)

UC#	KPI	AS-IS value BEFORE	AS-IS value FINAL (M39)	TO-BE value	STATUS
1: Co-Creation Introduction for SMEs	Participants in the pilot activities	8	115	100	ACHIEVED
	Consumer goods sectors addressed	0	3	1	ACHIEVED

	Customer-driven products manufactured in cMDFs	0	2	2	ACHIEVED
	Community members as beneficiaries of co-creation training	0	80	50	ACHIEVED
2: Machinery Training	Amount of digitized training material	Not yet collected	3	5% higher than AS-IS value	ACHIEVED
	Number of available virtual workshops	Not yet collected	2	5	
	Digital Fablab Kit	0	1	1	ACHIEVED
	Makers who complete sample projects with material, machinery or tools they have not used before	0	13	10	ACHIEVED
3: Guided Product Development as a Service	Demand-driven sharing economy business models	0	1	1	ACHIEVED
	Number of startups consulted	0	17	20	ACHIEVED
	Improved time to market of products	TBD through web search	4-8W	Lower than AS-IS value	ACHIEVED
	Makers and consumers involved in the co-design of products	0	95	20	ACHIEVED
	Startups' perceived ability to apply collective intelligence principles for the co-design on new products	0	9	20% higher than AS-IS value	ACHIEVED
	Development costs for new products	TBD through web search	250k	Lower than AS-IS value	ACHIEVED
4: IoT Kit	Consumer goods sectors addressed	0	4	3	ACHIEVED
	Customer-driven products manufactured in cMDFs	0	2	2	ACHIEVED
	Validated, market ready products	0	2	1	ACHIEVED

4.2.4. Impact Assessment

Over the course of the iPRODUCE project, the German cMDF's use cases improved in terms of the previously defined KPIs.

Use Case 1 – Co-Creation Introduction for SMEs, 9 different pilot activities were carried out, involving 115 participants (KPI-6). 7 of these activities had aspects of various co-creation trainings from which 80 community members benefited (KPI-28). 4 different customer-driven products were manufactured in the cMDFs (KPI-12), which addressed 3 different consumer goods sectors (KPI-10).

Use Case 2 – Machinery Training, 3 different trainings were set up, all of them coming with digitised training material. Two of them are available as virtual workshops. 13 makers participated in these training sessions. These factors relate to KPIs that were revised during the project. As part of this use case, the Digital FabLab Kit was developed (KPI-8).

Use Case 3 – Guided Product development as a service. This has in the end turned out to be the highest contributor of revenues and margins. About 30 companies consulted, from entrepreneur to Multinationals. MSB reached very high customer satisfaction. MSB likes this intellectually demanding business very much, where they must be very flexible.

Use Case 4 – MSB IoT Education kit. MSB considers they has lost 50.000€ in this kit due to:

- Corona stopped us for 2 years performing the onsite trainings.
- Ongoing lack of chips and heavily increased hardware cost vs. initial projections.
- Burn-out of the related project manager.

Therefore, MSB dropped the project. Nevertheless, MSB has gained knowledge and a network of local entities investing in educational workshops, of which MSB sells >10 per year, securing constant revenues.

4.3. French cMDF

4.3.1. Preliminary Tests and OpIS Technologies Involved

The time dedicated to the search for partners has been improved thanks to the OpIS platform, so once the skills of the partners are registered in the platform, the search and selection of the right partners is straightforward. However, given that the network of partners in the matchmaking database has not been very strong during the evaluation period and some activities had to be made manually, the search took a couple of weeks. The Marketplace and the Mobile App have impacted the number of gathered opinions related to the evaluation of the prototypes. Also, the Marketplace and Matchmaking have increased the number of actors involved. The visibility and accessibility of the activities and equipment of the FabLab has been improved through the communication with partners from other cMDFs as well as the iPRODUCE web resources, so users could access the training for feedback. Apart from this, it should be noted that the quantity of digitised training material was achieved not by using the Video Intelligence tool but a different approach.

4.3.2. Midterm Evaluation

Table 31 KPI-based validation results of the French cMDF at mid-term (M29)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value MID-TERM (M29)	TO-BE value	STATUS
USE CASE 2 : Co-creation from idea to product for mobility entrepreneurs project	Time spent searching for the right partner	≈ 20 to 35 days	≈ 20 days	< 15 days	-
	Time for the collaborative management of complete prototype process	≈ 9 months for a project of intermediary complexity (ex: Tenkey - for a bike side car)	N/A (only on-going projects at this stage)	20% less than the As-IS Value.	-
	Time between the manufacturer first contact and the final prototype production	≈ 13 months for a project of intermediary complexity (ex: Tenkey - for a bike side car)	N/A (only on-going projects at this stage)	30% less than the As-IS Value.	-
	Number of opinions assessing the virtual or physical prototype	2 (for virtual prototype)	N/A (only on-going projects at this stage)	2-3 time higher than the as-is value.	-
	Number of actors involved in the project	Usually 1 (Individual project)	2 to 3 (or more)	2 to 3 (collaborative project)	ACHIEVED
	Effectiveness and quality of collaborative manufacturing outputs	N/A	N/A (no questionnaire can be administered at this stage)	Greater than 80%	-

USE CASE 1: Digitalization of FabLab Training Material	Time of the FabLab manager allocated to basic training.	from ≈ 0.5 day per basic training (ex: additive manufacturing) to ≈ 1 day for complex training (pilot line) per session	no change	20% lower than AS-IS value	-
	Visibility and accessibility of the FabLab activities and equipment.	Local level only	Gain in the FabLab visibility through the iPRODUCE project (but still 0 "view" through the platform as not implemented yet)	Number of "views" got through the iPRODUCE platform.	-
	Amount of digitized training material.	0	on-going (but not finalized)	2-3 digitalized tutorials per FabLab	-
	Increase of the FabLabs users' satisfaction.	N/A	N/A (no questionnaire can be administered at this stage)	Greater than 80%	-
	Time spent to digitalize a tutorial.	N/A	on-going (but not finalized)	25% lower than AS-IS value	-
	Number of users trained by the FabLab.	≈ 15 users per basic training (ex: additive manufacturing) and ≈ 1 user per complex training (ex: pilot line)	no change	10% higher than the as is value	-

In many KPI values, this was setup to N/A (only on-going projects at this stage).

4.3.3. Final Evaluation

Table 32 KPI-based validation results of the French cMDF at final round (M39)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value FINAL (M39)	TO-BE value	STATUS
USE CASE 2: Co-creation from idea to product for mobility entrepreneurs project	Time spent searching for the right partner	≈ 20 to 35 days	< 15 days	< 15 days	ACHIEVED
	Time for the collaborative management of complete prototype process	≈ 9 months for a project of intermediary complexity (ex: Tenkey - for a bike side car)	N/A	20% less than the As-IS Value.	
	Time between the manufacturer first contact and the final prototype production	≈ 13 months for a project of intermediary complexity (ex: Tenkey - for a bike side car)	N/A	30% less than the As-IS Value.	
	Number of opinions assessing the virtual or physical prototype	2 (for virtual prototype)	5	2-3 time higher than the as-is value.	ACHIEVED
	Number of actors involved in the project	Usually 1 (Individual project)	2 to 3	2 to 3 (collaborative project)	ACHIEVED
	Effectiveness and quality of collaborative manufacturing outputs	N/A	N/A	Greater than 80%	

USE CASE 1 : Digitalization of FabLab Training Material	Time of the FabLab manager allocated to basic training.	from ≈ 0.5 day per basic training (ex: additive manufacturing) to ≈ 1 day for complex training (pilot line) per session	1 hour for one time	20% lower than AS-IS value	ACHIEVED
	Visibility and accessibility of the FabLab activities and equipment.	Local level only	Available on the European level (iPRODUCE Network)	Number of "views" got through the IPRODUCE platform.	ACHIEVED
	Amount of digitized training material.	0	2	2-3 digitalized tutorials per FabLab	ACHIEVED
	Increase of the FabLabs users' satisfaction.	N/A	N/A	Greater than 80%	
	Time spent to digitalize a tutorial.	N/A	1 hour	25% lower than AS-IS value	
	Number of users trained by the FabLab.	≈ 15 users per basic training (ex: additive manufacturing) and ≈ 1 user per complex training (ex: pilot line)	1	10% higher than the as is value	

4.3.4. Impact Assessment

In conclusion, the French cMDF encountered challenges in achieving their KPIs due to the delayed arrival of the digital tools and platforms they planned to use. This hindered their ability to track their progress towards their KPIs within the original timeframe and attract new partners to their network. However, they were able to find alternative ways to carry out their use cases and noticed improvements in various KPIs despite the difficulties.

They also learned that their use cases were too general, which made it challenging to compare different projects with and without the use of the platform. Moving forward, French cMDF recognizes the importance of choosing more specific use cases that allow for more accurate tracking of their progress towards their KPIs.

The French cMDF is confident that with the next releases of the digital tools and platform, they would be able to achieve their KPIs and bring more partners into their network.

4.4. Italian cMDF

4.4.1. Preliminary Tests and OpIS Technologies Involved

The Generative Design Platform enables the hosting and management of proposals. The increase of the number of proposals is expected to be achieved thanks to the Hackathon arranged with college students and makers. The Marketplace also impacts on this aspect and in the reduction of the time dedicated to appropriate partners. During the Hackathon new users are planned to be registered in the platform using the Agile Data Analytics, which increased the number of actors involved in the co-design phase.

The number of opinions to assess the virtual prototype is expected to be increased through the surveys created and replied during the Hackathon, using the Marketplace, the Mobile App, and the Agile Data Analytics, which also enabled the extraction of data after the Hackathon improving the time for collaborative management. These tools also enabled to validate the improvement of the stakeholders' satisfaction during the Hackathon, where the survey was created and then replied by the participants.

Also, the number of proposals for conceptual designs is expected to be increased, and the partners' searching time reduced, using the Marketplace. In general, the OpIS platform reduces the time from the first contact with the manufacturer and the production of the prototype.

4.4.2. Midterm Evaluation

Table 33 KPI-based validation results of the Italian cMDF at mid-term (M29)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value MID-TERM (M29)	TO-BE value	STATUS
Collaborative Engineering in Customer-Driven Robo-Shaker	Number of proposals for the conceptual mechanical design based on the initial idea	1 proposal	2 proposals	>= 2 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days (excluding the formality of signing the contract)	≈ 15 days (excluding the formality of signing the contract)	< 5 days	-

	Number of actors in the co-design phase	2 actors (Manufacturer, designer)	5 partners (FabLab, designers)	>= 10 actors	-
	Number of opinions assessing the virtual prototype	≈4 opinions (internal experts of cMDF and the client)	10 opinions	>= 10 opinions	ACHIEVED
	Improve the time for the collaborative management of complete process	≈60 working days: management (administrative, technical)	≈60 working days: management (administrative, technical)	≈ 30 working days	-
	Time between the manufacturer first contact and the final prototype production	≈90 working days Contact with designers, planning, final production (prototype alpha)	≈90 working days Contact with designers, planning, final production (prototype alpha)	< 60 working days	-
	Stakeholder satisfaction	85%	85%	>90%	-
Collaborative Engineering in Customer-Driven Watering System	Number of proposals for the conceptual design based on the initial idea	1 proposal	3 proposals	>= 2 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days (excluding the formality of signing the contract)	≈ 15 days (excluding the formality of signing the contract)	< 5 days	-
	Number of actors in the co-design phase	2 actors (Manufacturer, designer)	5 partners (FabLab, designers)	>= 10 actors	-
	Number of opinions assessing the virtual prototype	≈4 opinions (internal experts of cMDF and	10 opinions	>= 10 opinions	ACHIEVED

	the client)				
	Improve the time for the collaborative management of complete process	≈60 working days: management (administrative, technical)	≈60 working days: management (administrative, technical)	≈ 30 working days	-
	Time between the manufacturer first contact and the final prototype production	≈90 working days Contact with designers, planning, final production (prototype alpha)	≈90 working days Contact with designers, planning, final production (prototype alpha)	< 60 working days	-
	Stakeholder satisfaction	85%	85%	>90%	-

4.4.3. Final Evaluation

Table 34 KPI-based validation results of the Italian cMDF at final round (M39)

PROTOTYPE	KPI	AS-IS value BEFORE	AS-IS value FINAL (M39)	TO-BE value	STATUS
Collaborative Engineering in Customer-Driven Robo-Shaker	Number of proposals for the conceptual mechanical design based on the initial idea	1 proposal	5 proposals	>= 2 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days (excluding the formality of signing the contract)	≈1 working day	< 5 days	ACHIEVED
	Number of actors in the co-design phase	2 actors (Manufacturer, designer)	50 (students, FabLab, designers, SMEs)	>= 10 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	≈4 opinions (internal experts of cMDF and	10 opinions	>= 10 opinions	ACHIEVED

		the client)			64
	Improve the time for the collaborative management of complete process	≈60 working days: management (administrative, technical)	≈1 working day	≈ 30 working days	ACHIEVED
	Time between the manufacturer first contact and the final prototype production	≈90 working days Contact with designers, planning, final production (prototype alpha)	≈15 working days (expected)	< 60 working days	ACHIEVED
	Stakeholder satisfaction	85%	100%	>90%	ACHIEVED
Collaborative Engineering in Customer-Driven Watering System	Number of proposals for the conceptual design based on the initial idea	1 proposal	3 proposals	>= 2 proposals	ACHIEVED
	Reduction of the time spent searching for the right partner	≈ 15 days (excluding the formality of signing the contract)	≈1 working day	< 5 days	ACHIEVED
	Number of actors in the co-design phase	2 actors (Manufacturer, designer)	30 (students, FabLab, designers, SMEs)	>= 10 actors	ACHIEVED
	Number of opinions assessing the virtual prototype	≈4 opinions (internal experts of cMDF and the client)	10 opinions	>= 10 opinions	ACHIEVED
	Improve the time for the collaborative management of complete process	≈60 working days: management (administrative, technical)	≈1 working day	≈ 30 working days	ACHIEVED
	Time between the manufacturer first contact and the final prototype production	≈90 working days Contact with designers, planning, final	≈30 working days (expected)	< 60 working days	ACHIEVED

		production (prototype alpha)			
	Stakeholder satisfaction	85%	100%	>90%	ACHIEVED

4.4.4. Impact Assessment

The Italian cMDF has used two demonstration Use Cases for the evaluation and testing of the SW tools developed within the framework of the iPRODUCE project.

Those two are mechatronics examples (described in D2.7) based on real projects realized by members of the Italian community, which has allowed us to retrieve in a straightforward manner the reference values used to describe the status of the development process before the introduction of the iPRODUCE platform facilities.

The build-up of the cMDF community, during the project's development, has allowed it to evaluate the mid-term KPIs, when several "virtual" meetings have been arranged to test the platform while "simulating" the development of the Use Cases.

Finally, for the evaluation of the tools and the consolidation of the KPIs, the Italian cMDF decided to organise two separate events and to engage several potential users of the iPRODUCE Platform as beta testers of the different SW tools.

Manyfold motivation behind this choice: firstly, to have several "new" users without any bias related with the evolution of the platform, secondly, to have a larger number of fresh and new ideas to bring in the community and, finally, to start-up a community of makers and DIY (do-it-yourself) project enthusiasts around the cMDF.

The two events took place in the form of hackathons addressed to the community of university students with strong interests in mechatronics and DIY movement more in general.

In the end, the hackathons got a larger than expected engagement, 30 students plus members of the jury and iPRODUCE project stakeholders participated in the first event (targeting Use Case nr.1), while more than 60 people were registered during the second one (targeting Use Case nr.2).

This resulted in 5 proposals for the first Use Case, the mechatronic rocking cot, that were evaluated by a jury where the representative of a SME of those present played the role of the main contractor and expressed its satisfaction with the winning result. Finally, altogether, we were able to estimate the time and effort required to bring the product to "life".

Same approach was used in the second event and again the all the jury member, after the evaluation, collaborated to estimate time and effort for the implementation.

During both events each group of participants were requested to use the iPRODUCE SW tools (even if they were in an earlier stage of development) allowing us to retrieve quantitative KPIs where possible. This kind of testing allowed us also to collect feedback for the SW developer.

4.5. Greek cMDF

4.5.1. Preliminary Tests and OpIS Technologies Involved

The AR/VR Toolkit has been used to increase the number of proposals for appearance customisation on the conceptual design, by changing the colour, the type of material and the design of the prototype. The Marketplace, enhanced by the Matchmaking, has allowed a reduction in the time spent searching for appropriate partners. In addition, the number of actors taking part in the co-design phase has evolved thanks to the OpIS platform tools by creating a team in the Marketplace. Finally, the adoption of the AR/VR Toolkit and the Marketplace has enabled the reduction of the time between the first contact with the producer and the manufacturing of the final prototype. All the above, basically applies to all the use cases considered in the Greek cMDF: the IoT-based orthopaedic back brace, the splints for fractures, the splints for pets, the customised face shields, the 3D printed smart luminous artefacts , and the 3D printed (bio) scaffolds.

4.5.2. Midterm Evaluation

Table 35 KPI-based validation results of the Greek cMDF at mid-term (M29)

PROTOTYPE	KPI	AS-IS BEFORE	AS-IS value MID-TERM (M29)	TO-BE	STATUS
IoT-based Orthopaedic back brace	Number of proposals for appearance customization based on the initial conceptual design (e.g., size, shape, colour, engraved logo/name, type of straps etc.)	1	2	> 3	-
	Reduction of the time spent searching for the right partner	15 days	N/A	< 2 days	-
	Number of actors in the co-design phase	2	4 (CERTH and Aidplex on OpIS platform, and 2 doctor/patient not on OpIS)	> 3	ACHIEVED
	Number of participants in surveys assessing the virtual prototype	2	2	> 20	-

	Time between the manufacturer first contact and the final prototype production	45 days	N/A	< 15 days	- 67
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction in open innovation	N/A	N/A	> 30%	-
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value MID-TERM (M29)**	**TO-BE**	
Splints for fractures	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, engraved logo/name, type of straps etc.)	1	2	> 3	-
	Number of proposals for size customization based on the initial conceptual design	1	2	> 3	-
	Reduction of the time spent searching for the right partner	15 days	N/A	< 2 days	-

	Number of actors in the co-design phase	2	3 (CERTH and Aidplex on OpIS platform, and 1 doctor/patient not on OpIS)	> 2	ACHIEVED
	Number of participants in surveys assessing the virtual product	2	2	> 20	-
	Time between the manufacturer first contact and the final prototype production	30 days	N/A	< 10 days	-
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction in open innovation	N/A	N/A	>20	-
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value MID-TERM (M29)**	**TO-BE**	
Splints for pets	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, type of straps etc.)	1	2	> 3	-
	Number of proposals for size customization based on the initial conceptual design	1	2	> 3	-
	Reduction of the time spent searching for the right partner	15 days	N/A	< 2 days	-
	Number of actors in the co-design phase	2	3 (CERTH and Aidplex	> 2	ACHIEVED

PROTOTYPE	KPI	AS-IS	AS-IS value MID-TERM (M29)	TO-BE	
			on OpIS platform, and 1 Vet not on OpIS)		69
	Number of participants in surveys assessing the virtual product	2	2	> 20	-
	Time between the manufacturer first contact and the final prototype production	45 days	N/A	< 10 days	-
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction in open innovation	N/A	N/A	>20	-
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value MID-TERM (M29)**	**TO-BE**	
Customized face shields	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, type of strips etc.)	1	2	> 3	-
	Number of proposals for size customization based on the initial conceptual design	1	2	> 3	-
	Reduction of the time spent searching for the right partner	15 days	N/A	< 2 days	-
	Number of actors in the co-design phase	2	3 (CERTH and Aidplex on OpIS platform, and 1 doctor/patient not on OpIS)	> 2	ACHIEVED
	Number of participants in surveys assessing the virtual product	2	2	> 20	-
	Time between the manufacturer first contact and the final prototype production	21 days	N/A	< 7 days	-
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction in open innovation	N/A	N/A	>20	-
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value**	**TO-BE**	

			MID-TERM (M29)		
3D printed smart luminous artifacts	Number of proposals for appearance customization based on the initial conceptual design (e.g., figure of artifact, colour, engraved logo/name etc.)	1	2	> 3	-
	Number of proposals for size customization (of artifact and electronics housing) based on the initial conceptual design	1	N/A	> 3	-
	Reduction of the time spent searching for the right partner	15 days	3 (CERTH and Aidplex on OpIS platform, and 1 school not on OpIS)	< 2 days	-
	Number of actors in the co-design phase	2	2	> 4	-
	Number of participants in surveys assessing the virtual product	N/A	N/A	> 30	-
	Time between the manufacturer first contact and the final prototype production	30 days	N/A	< 10 days	-
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction on training skills	N/A	N/A	>50%	-
	Improve user satisfaction in open innovation	N/A	N/A	>20	-
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value MID-TERM (M29)**	**TO-BE**	
3D printed (bio) scaffolds	Number of proposals for appearance customization based on the initial conceptual design (e.g., lattice structure, material, etc.)	1	2	> 3	-
	Number of proposals for size customization based on the initial conceptual design	1	2	> 3	-
	Reduction of the time spent searching for the right partner	15 days	N/A	< 2 days	-
	Number of actors in the co-	2	3	>2	ACHIEVED

design phase			(CERTH and Aidplex on OpIS platform, and 1 researcher not on OpIS)		71
	Number of participants in surveys assessing the virtual product	N/A	2	>10	-
	Time between the manufacturer first contact and the final prototype production	21 days	N/A	< 7 days	-
	Improve product innovation and co-creation activities	N/A	N/A	≈ 20%	-
	Improve user satisfaction in open innovation	N/A	N/A	>20	-

4.5.3. Final Evaluation

Table 36 KPI-based validation results of the Greek cMDF at final round (M39)

PROTOTYPE	KPI	AS-IS BEFORE	AS-IS value FINAL (M39)	TO-BE	STATUS
IoT-based Orthopaedic back brace	Number of proposals for appearance customization based on the initial conceptual design (e.g., size, shape, colour, engraved logo/name, type of straps etc.)	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right partner	15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2	3	> 3	ACHIEVED
	Number of participants in surveys assessing the virtual prototype	2	Pending until the Hackathon	> 20	

	Time between the manufacturer first contact and the final prototype production	45 days	10 Business Days	< 15 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	
	Improve user satisfaction in open innovation	N/A	Pending until the Hackathon	> 30%	
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value FINAL (M39)**	**TO-BE**	**STATUS**
Splints for fractures	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, engraved logo/name, type of straps etc.)	1	3	> 3	ACHIEVED
	Number of proposals for size customization based on the initial conceptual design	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right partner	15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2	3	> 2	ACHIEVED
	Number of participants in surveys assessing the virtual product	2	Pending until the Hackathon	> 20	
	Time between the manufacturer first contact and the final prototype production	30 days	10 Business Days	< 10 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	

| | Improve user satisfaction in open innovation | N/A | Pending until the Hackathon | >20 | |

PROTOTYPE	KPI	AS-IS	AS-IS value FINAL (M39)	TO-BE	STATUS
Splints for pets	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, type of straps etc.)	1	3	> 3	ACHIEVED
	Number of proposals for size customization based on the initial conceptual design	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right partner	15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2	3	> 2	ACHIEVED
	Number of participants in surveys assessing the virtual product	2	Pending until the Hackathon	> 20	
	Time between the manufacturer first contact and the final prototype production	45 days	10 Business Days	< 10 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	
	Improve user satisfaction in open innovation	N/A	Pending until the Hackathon	>20	
PROTOTYPE	KPI	AS-IS	AS-IS value FINAL (M39)	TO-BE	STATUS
Customized face shields	Number of proposals for appearance customization based on the initial conceptual design (e.g., shape, colour, type of strips etc.)	1	3	> 3	ACHIEVED
	Number of proposals for size customization based on the initial conceptual design	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right	15 days	1	< 2 days	ACHIEVED

PROTOTYPE	KPI	AS-IS	AS-IS value FINAL (M39)	TO-BE	STATUS
	partner				
	Number of actors in the co-design phase	2	3	> 2	ACHIEVED
	Number of participants in surveys assessing the virtual product	2	Pending until the Hackathon	> 20	
	Time between the manufacturer first contact and the final prototype production	21 days	10 Business Days	< 7 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	
	Improve user satisfaction in open innovation	N/A	Pending until the Hackathon	>20	
PROTOTYPE	**KPI**	**AS-IS**	**AS-IS value FINAL (M39)**	**TO-BE**	**STATUS**
3D printed smart luminous artifacts	Number of proposals for appearance customization based on the initial conceptual design (e.g., figure of artifact, colour, engraved logo/name etc.)	1	3	> 3	ACHIEVED
	Number of proposals for size customization (of artifact and electronics housing) based on the initial conceptual design	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right partner	15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2	3	> 4	
	Number of participants in surveys assessing the virtual product	N/A	Pending until the Hackathon	> 30	
	Time between the manufacturer first contact and the final prototype production	30 days	10 Business Days	< 10 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	
	Improve user satisfaction on training skills	N/A	Pending until the Hackathon	>50%	
	Improve user satisfaction in open innovation	N/A	Pending until the Hackathon	>20	

PROTOTYPE	KPI	AS-IS	AS-IS value FINAL (M39)	TO-BE	STATUS
3D printed (bio) scaffolds	Number of proposals for appearance customization based on the initial conceptual design (e.g., lattice structure, material, etc.)	1	3	> 3	ACHIEVED
	Number of proposals for size customization based on the initial conceptual design	1	3	> 3	ACHIEVED
	Reduction of the time spent searching for the right partner	15 days	1	< 2 days	ACHIEVED
	Number of actors in the co-design phase	2	3	>2	ACHIEVED
	Number of participants in surveys assessing the virtual product	N/A	Pending until the Hackathon	>10	
	Time between the manufacturer first contact and the final prototype production	21 days	10 Business Days	< 7 days	ACHIEVED
	Improve product innovation and co-creation activities	N/A	Pending until the Hackathon	≈ 20%	
	Improve user satisfaction in open innovation	N/A	Pending until the Hackathon	>20	

4.5.4. Impact Assessment

If we evaluate the KPIs defined at the beginning of the project with the values currently obtained (at the end of the project) from each UC we can conclude for:

Use Case 1 – IoT-based Orthopaedical back brace: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 2 physical prototypes were produced and presented in various local events.

Use Case 2 – Splints for fractures: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 1 physical prototype was produced and presented in various local events.

Use Case 3 – Splints for pets: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 1 physical prototype was produced and presented in various local events.

Use Case 4 – Customized face shields: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 2 physical prototypes were produced and presented in various local events.

Use Case 5 – 3D printed smart luminous artifacts: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 2 physical prototypes were produced and presented in various local events. Additionally, the idea was developed and improved during the Greek cMDF competition, where the participants had the opportunity to attend a demonstration of the iPRODUCE OpIS platform. This UC was also presented in the Conference on Progress in Digital and Physical Manufacturing" (ProDPM '21), entitled: "3D Printed Smart Luminous Artifacts".

Use Case 6 – 3D printed (bio) scaffolds: 3 different designs were made from the initial idea, reducing the collaboration time due to the OpIS functionalities, involving more stakeholders than the cMDF partners (Core group members) using the tools for improving the initial product idea. 1 physical prototype was produced for four diverse designs and presented in various local events. This work was also presented in the Conference on Progress in Digital and Physical Manufacturing" (ProDPM '21), entitled: "The Mechanical Performance of Additive Manufacturing Silica Lattice Structures".

5. Main conclusions

This chapter aims at describing and summarising the most relevant conclusions collected from both the heuristic assessment and the KPI-based validation. The results can be better grasped by visualising the tables and graphs showing the results in an overall approach and reviewing the most relevant conclusions extracted from the users' comments.

5.1. Overall conclusions from the Heuristic Evaluation

For the first evaluation round, not all the tools were considered, rather only those with enough maturity level. Each tool was evaluated separately.

Table 37 Overall rating at the mid-term evaluation

Generative Design Platform	**64,64**	**IMPROVE**
IPR & Transaction Management	**56,43**	**IMPROVE**
Marketplace	**69,68**	**IMPROVE**
Matchmaking	**58,64**	**IMPROVE**
AR (Mobile App Client)	**48,24**	**FAILED**
VR (VR Client)	**50,33**	**IMPROVE**
Mobile App for social media	**66,56**	**IMPROVE**
Video Intelligence	**60,07**	**IMPROVE**
CMDF Training Flow	**62,22**	**IMPROVE**
CMDF Training View	**59,57**	**IMPROVE**
Process Automation Tool	**62,17**	**IMPROVE**
Agile Data Analytics	N/A	N/A

The Table 37 above shows the eleven tools evaluated in the mid-term round with its corresponding rating. From these results, it can be stated that all the tools required (at that time), at best, some improvements to get an appropriate level of user satisfaction.

The Figure 7 below shows summarises the average level of acceptance (PASSED) of the full set of tools evaluated in the mid-term. This allows one to get a quick vision of what heuristic principles have been properly covered and what needs to be significantly addressed.
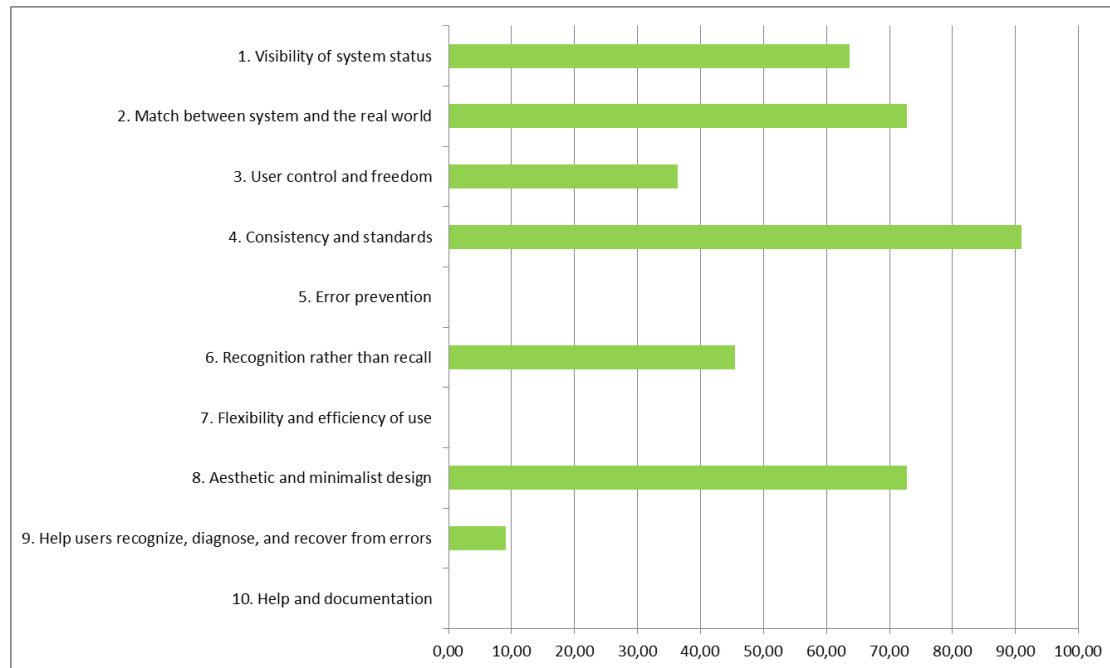
Figure 7 Acceptance level per heuristic principle in the mid-term

The management of errors (from both the prevention and the recovering perspective), the flexibility and efficiency during the use and the support to the users are the weakest points in this regard.

While for the first evaluation round the Agile Data Analytics was not available for testing, in the final round it was the Process Automation Tool that could not be assessed as previously explained in the corresponding heuristic evaluation. This must be considered and therefore no improvement between rounds could be measured for these tools.

Table 38 Overall rating at the final evaluation

Generative Design Platform	**59,51**	**IMPROVE**
IPR & Transaction Management	**65,70**	**IMPROVE**
Marketplace	**73,32**	**IMPROVE**
Matchmaking	**75,28**	**PASSED**
AR (Mobile App Client)	**61,32**	**IMPROVE**
VR (VR Client)	**54,70**	**IMPROVE**
Mobile App for social media	**74,97**	**IMPROVE**
Video Intelligence	**66,31**	**IMPROVE**
CMDF Training Flow	**70,57**	**IMPROVE**
CMDF Training View	**64,67**	**IMPROVE**
Process Automation Tool	N/A	N/A
Agile Data Analytics	**72,34**	**IMPROVE**

The Table 38 above shows the eleven tools evaluated in the final round indicating its rating. As in the mid-term evaluation, from the results it can be stated that almost all the tools need some improvements to get an appropriate level of satisfaction for the end users.

The Figure 8 below summarises the average level of acceptance (PASSED) of the full set of tools evaluated in the final round. As in the mid-term graph, this one provides a comprehensive vision of to what extent the heuristic principles have been covered.
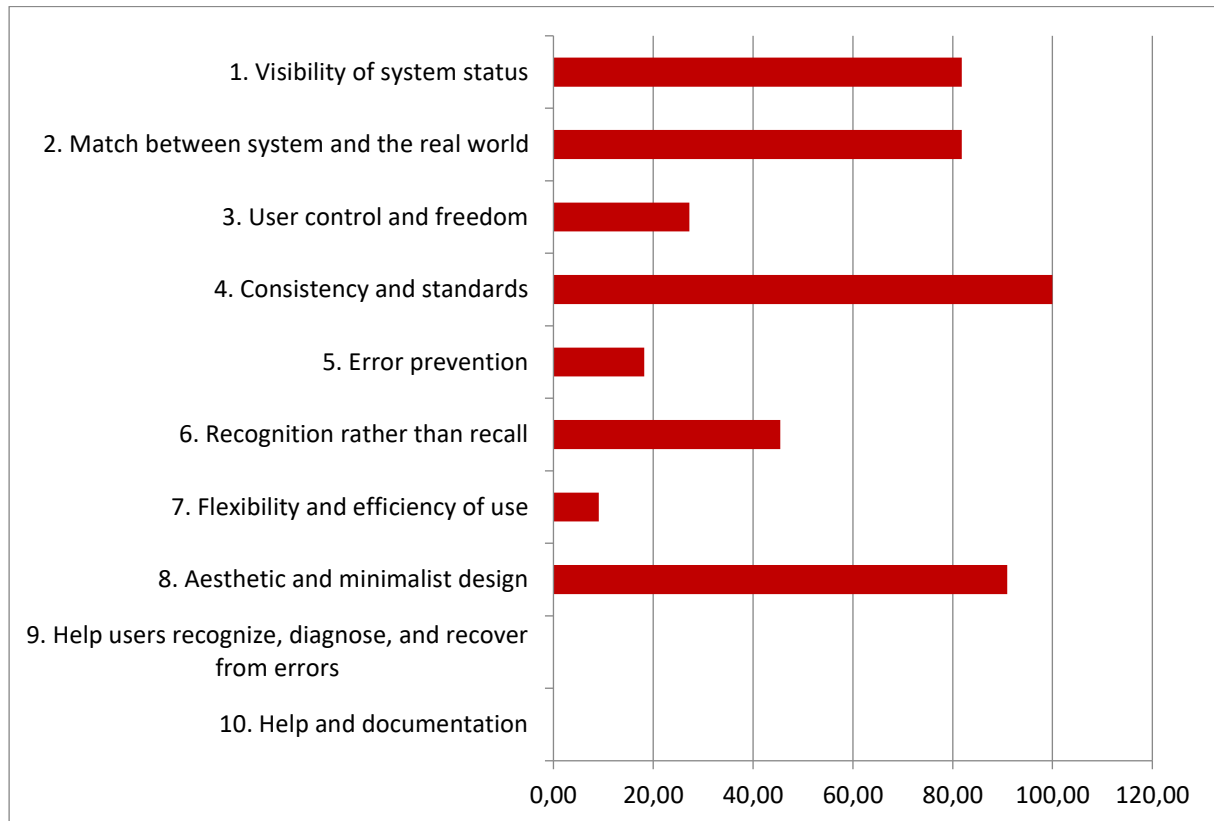

Figure 8 Acceptance level per heuristic principle in the final round

It can be concluded that the Matchmaking (which indeed got the best overall score) and those above score 70 (Mobile App for social media, Marketplace, Agila Data Analytics and CMDF Training Flow) are those that obtained the best ratings.

Besides this, considering that the heuristic assessment has performed a tool-oriented evaluation in a granular way, some aspects related to the overall platform should be taken into consideration by the developers. All the tools should include tooltips (on mouse-hover) as a kind of popup info boxes, as this would be very useful for the users. Also, in most cases there is no option to recover or remember the password (i.e.: 'forgot password') in the login page. Some inconsistencies are often found in the layout, which to some extent prevents users of the integration feeling. The tools offer heterogeneous presentations: sometimes the menu is on the top while others on the left side and icons and pictures are quite different between tools. Even different layouts can be found within the same tool: one page contains the 'exit' button on the right side while the next page presents the same functionality represented by a backwards arrow on the left side. Issues like this create some confusion to the users, and the homogenisation of these aspects would solve these inconsistencies leading to a very better UX.
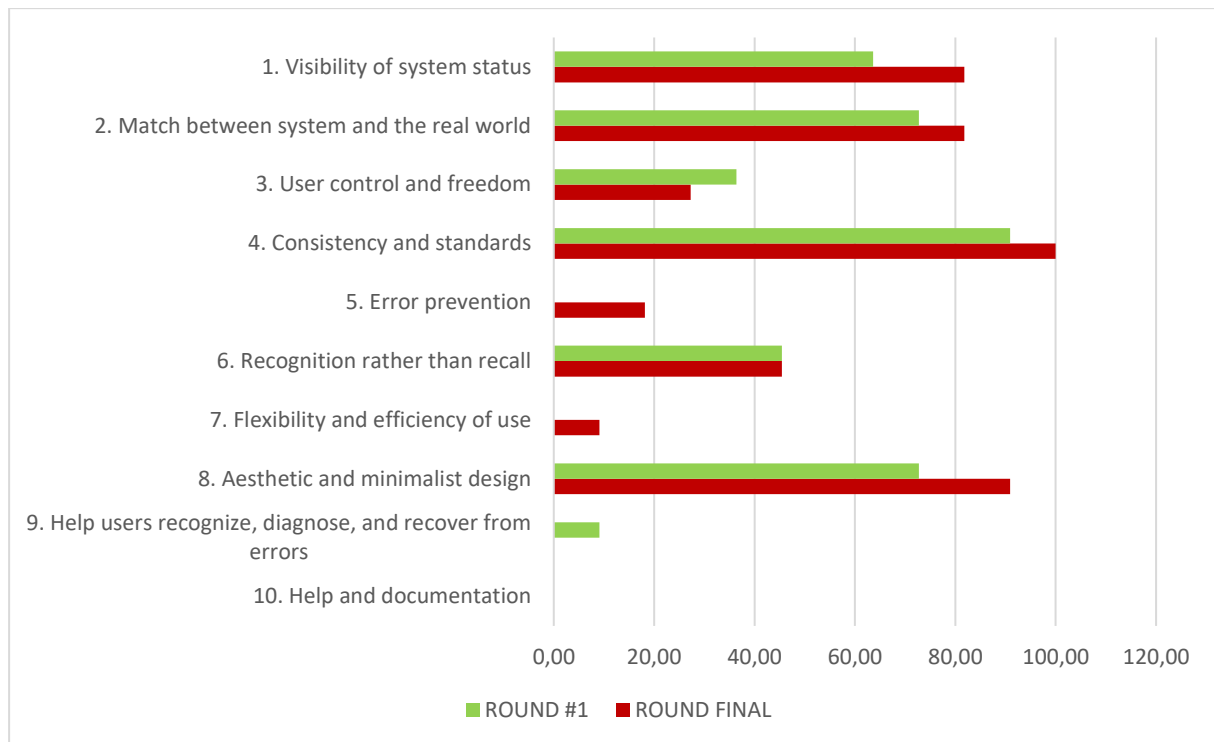
Figure 9 Comparison of acceptance level per heuristic principle between the first and final round

The Figure 9 above shows the comparison between the first and final round regarding the fulfilment of the heuristic´s principles. This has been calculated considering the ratio of 'pass' ratings for each parameter. As can be seen in the graph, the improvements have not been high but noticeable. They mainly affect the visibility, the proper use of pictures and concepts, the meeting with standards and the overall aspect of the tools.

Regarding the 'help and documentation' parameter – which can be repeatedly noted that this has been a common failure for virtually all the tools and has negatively impacted in its overall heuristic scores – this is expected to be prepared or under preparation when writing this document.

5.2. Overall conclusions from the KPIs Validation

As an overall statement, the functionalities provided by the OpIS platform have reduced the collaboration time, involved more stakeholders, and improved the product ideas conceived in the beginning of the project. These functionalities have also enabled the adaptation of the production based on the specifications gathered from the users and have facilitated the production of the corresponding prototypes.

The creation of training sessions consuming the generated material, adopting the collaborative creation approach, facilitates the addressing to heterogeneous sectors.

However, it should be noted that the delayed release of many tools of the OpIS platform caused that the measuring and the evaluation of the KPIs became a challenging task. Moreover, it was detected that the scope of some use cases originally defined in the project was too general. This often hindered the execution of a comparative analysis between projects and performing a more accurate tracking of the implementation process making use of the KPI approach.

Besides this, many events have been organized to engage users, do testing and collect feedback about the definition of the prototypes and the use of the tools of the OpIS platform. Regarding this user engagement, it is important to remark the involvement of 'new' users, who were not aware of the evolution of the tools under development, what also brings many new and valuable ideas to the communities. The hackathons arranged during the project involved makers, college students and other members interest in the DIY movement. These events also achieved a large engagement of members (larger than expected), raising also more proposals than those initially expected. This enabled the evaluation of this proposals and the estimation of the calculations related to the time and effort required to execute them. The testing carried out during these events has enabled the collection of feedback for technical partners to improve their tools.

In some cases, the physical prototypes were presented at local events and the participants had the opportunity to attend a demonstration of the iPRODUCE OpIS platform.

6. OpIS Map

The Figure 10 below shows the OpIS Map, what means a quick way to present all the cMDFs and its use cases, the involved stakeholders, and the list of all the OpIS components used.

cMDF	UC	PROTOTYPE BEING VALIDATED	MMC involved			OpIS Platform							
			MANUFACTURER	MAKER	CONSUMER	GENERATIVE DESIGN PLATFORM	AR/VR	MARKETPLACE	MATCHMAKING & AGILE NETWORK	DIGITAL FABLAB KIT	AGILE DATA ANALYTICS & VISUALIZATION SUITE	MOBILE APP	RICARDIAN TOOLKIT
Spanish	UC1	Intelligent Headboard	X		X	X	X	X	X	X	X	X	X
	UC2	Smart adjustable gamer chair	X		X		X	X	X	X	X	X	X
	UC3	3D printed components for assembling customized furniture		X			X	X	X	X		X	X
German	UC1	CoCreation – Introduction for SME's			X	X		X	X	X			
	UC2	Machinery Training		X	X	X	X	X	X				
	UC3	Guided Product Development as a Service (GPDaaS)				X		X	X	X			
	UC4	IoT Education Kit		X		X		X	X	X			
Italian	UC1	Collaborative Engineering in Customer-Driven Robo-Shaker	X	X	X	X	X	X	X	X	X	X	X
	UC2	Collaborative Engineering in Customer-Driven Watering System		X	X	X	X	X	X	X	X	X	X
Greek	UC1	IoT-based Orthopedic back brace	X		X	X	X	X	X		X	X	X
	UC2	Customized face shields	X		X	X	X	X	X		X	X	X
	UC3	Splints for fractures		X	X	X	X	X	X		X	X	X
	UC4	Splints for pets	X		X	X	X	X	X		X	X	X
	UC5	3D printed smart luminous artifacts		X	X	X	X	X	X	X	X	X	X
	UC6	3D printed (bio) scaffolds		X	X	X	X	X	X	X	X	X	X
Danish	UC1	Co-creation in schools	X	X	X						X		
	UC2	Distributed design market	X	X	X		X				X		
	UC3	Temporary Architecture	X	X	X		X				X		X
French	UC1	Digitalization of FabLab Training Material		X	X		X	X	X	X	X		X
	UC2	Co-creation from idea to product for mobility entrepreneurs project	X	X	X	X	X	X	X	X	X	X	X

Figure 10 Final OpIS Map view of all cMDF use cases

In general terms we can say that all the cMDFs have increased the usage of the tools/components in the validation of their KPIs, and this is a positive outcome. This is mainly since the tools work much better and, as result, the users are more confident and use them appropriately.

A great palpable example in all UCs is the use in all of them of the Marketplace and Matchmaking components. In other cases, the use of some tools was not thought of at the beginning and now they are used like for example the Mobile App or the Agile Analytics & Visualization Suite.

7. References

[1] iPRODUCE Consortium 2021. Grant agreement no: 870037. DT-FOF-05-2019: Deliverable 9.1. Evaluation Methodology Plan and Metrics.

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[6] iPRODUCE Consortium 2020. Grant agreement no: 870037. DT-FOF-05-2019: Deliverable 2.5. Definition of iPRODUCE Demonstration Framework.

Annex: Latest enhancement of tools based on users' heuristics assessment

Introduction about latest enhancements and last assessment

This D9.3 annex complements and extends the results of the work performed by partners in the evaluation activities of the tools of the Open Innovation Space (OpIS) of the iPRODUCE Social Manufacturing Framework, performed by the members of the cMDFs (collaborative Manufacturing Demonstration Facilities) and other partners of the project.

One of the main sections of the D9.3 deliverable has been the heuristic assessment, focused on the evaluation of tools from the user experience perspective. This was done in two different rounds: from the mid-term evaluation could be concluded the need for an overall improvement of the tools, while the final round demonstrated some improvements that increased the user satisfaction. However, even many problems found by the users during the assessment were fixed, the improvements achieved at that point were quite subtle and did not mean a significant overall improvement in the user experience, as reported in D9.3.

This annex illustrates the latest efforts done by technical partners to improve the implemented tools of the OpIS platform, as well as clarifications about some users' comments that enable to better understand the scope of some found issues and the underlying cause of some negative feedback retrieved in the performed heuristics evaluations. All these aspects are reported in the 'latest heuristics assessment' section. Besides this, the 'added functionalities' section includes the most relevant added functions claimed by the end users that have been implemented from the first evaluations of the tools. This is an important aspect to highlight because has increased a lot the satisfaction of the cMDF's users regarding the usage of the iPRODUCE tools.

Latest Heuristics Assessment

This section navigates inside each one of the evaluated tools providing an overall score table calculated from the user assessment. In the beginning of each tool section, the number of evaluators and the average overall scoring is indicated. It should be noted that not all questions could be answered by all the evaluators. Therefore, the score is calculated based on the positive/negative answers, without considering those that users could not submit and left unanswered. Also, if the user posted a comment indicating that such questions could not be properly assessed, this has not been considered for the final score. This applies to the error management, so this depends a lot on the specific usage scenario of the tools. The end of each tool chapter includes insightful comments by users organized in those aspects that the tool is failing or could be significantly improved.

Generative Design Platform (GDP)

Usability requests were integrated as Software Requirements Specifications for the coming versions after March 2023. The current version has the documentation available in PDF format inside the tool. There are tutorial videos and further information accessible in the OpIS platform.

IPR & Transaction Management

The **user control** has improved by making the buttons in the header work, which is composed by the dashboard, the documentation, and the contact information), and including a navigation to the iPRODUCE landing page when clicking on the logo. Moreover, before the last updates, the user could only watch the notifications once, while in the new version the user can inspect the notifications at any time and the username is always displayed.

Regarding the **prevention of errors**, a contact form has been added and messages can be successfully sent by the users to the corresponding technical team of the OpIS platform. The creation of new teams is now working and information about how to create them is displayed. In general, the system now provides feedback to the users and, even if some changes could be made to improve the frontend, the tool is much more intuitive than before.

The **recognition** aspect has been addressed by adding documentation and tooltips, and the efficiency has improved so the loading time has been significantly reduced. This can be easily perceived when inspecting the contracts. Also, a filter and sort dropdown buttons has been added to the dashboard, what provides a higher level of customization, meaning a great improvement, so the pagination and filters - now the contracts can be filtered by its status - are very valuable for users. A loading spinner has been also added to indicate the loading periods, and the documentation includes pictures which are meaningful for the users.

The **recovering from errors** issue is supported by the contact form added, so users could contact the technical team. Finally, a **documentation** page inside the tool, including text and pictures in web format, has been added to provide guidance to the users.
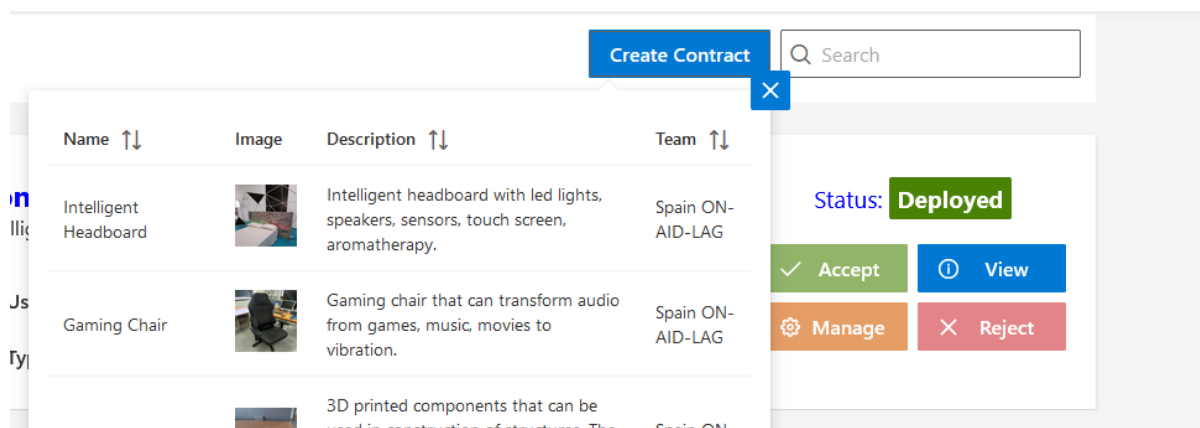

Figure 11 Creation of contracts through the IPR tool

As can be seen in Figure 11 above, now users can create new contracts without creating a new product. This is a useful feature because if a new user is added to the team, and the product was previously created, this user will not be part of the contract by default. However, if a new contract is created all the users from the team will be included in the contract.

MarketPlace

The video documentation and optionally deliverable D4.6 addresses the **error prevention** issue (i.e.: when uploading products through the tool).

Regarding the **efficiency of use**, the tool will implement notifications (bubble on the avatar) to indicate that a message has been successfully received. Some problems found (i.e.: no button to create a new team) have been addressed through the generated documentation, so this is related to how the process works (send invitation, select members of the team, etc.). Also, there is a

button to create products in the edit profile. Furthermore, regarding the customization of the presentation, the users can add as many text boxes and images as they want, as well as edit them with free text, which was a request from the users instead of using a dropdown lists. The response time issue has been derived so this is not directly related to the Marketplace tool, this occurs when clicking on buttons that redirect to other components. Same applies to the Change Password option. Also. the 'about' button available in the landing page does not work. In any case, the iPRODUCE logo of the tool is a button that redirects to the project website.

Regarding the **recognition and recovering from errors**, the mandatory fields are indicated in a grey box, and some problems found has been derived so they were not directly related to this tool. Furthermore, successful tests were made to check some problems previously found related to the reception of notifications and the message exchange between users.

Some problems about the refreshing of the information were detected, so the new teams created did not automatically appear in the list. This has been properly addressed in the latest version of the Marketplace.
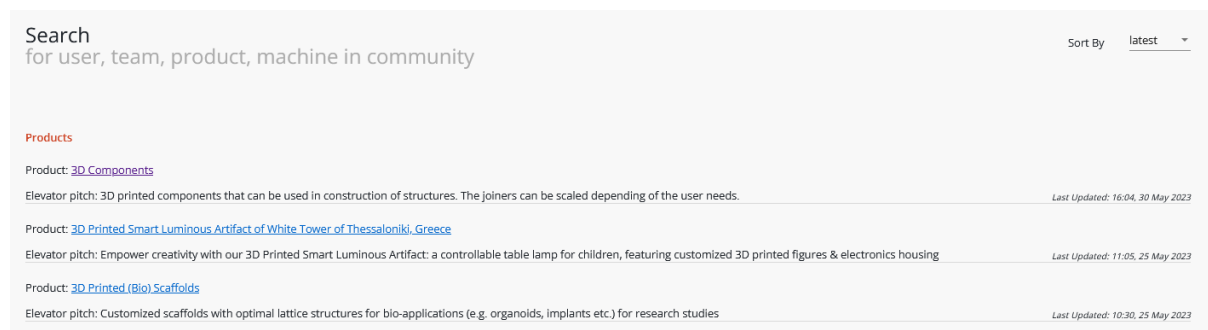

Figure 12 Filtering capability in the MarketPlace

As can be seen in Figure 12 above, the sorting functionality (i.e.: by 'most recent') was added, with filtering displaying the date of the latest update.

Furthermore, the problem found when the user clicks in the 'Matchmake' option has been derived and addressed by the Matchmaking tool. Finally, the **documentation** can be found in deliverable D4.6 and through videos, considering these last ones the most recommended as user guidance. However, they are available in the project website, not inside the tool or the OpIS platform.

Matchmaking

Regarding problems found with the **user control**, the tool will include a button to navigate to the marketplace, and a reset button. Also, feature has been implemented to retrieve all users by typing the '*' symbol into the free text box, as well as implemented fixes for bugs reported in the Hackathons. It should be also noted that the logout button, that some users could not find, was also removed upon request.

About the **prevention of errors**, some problems detected with the email addresses. It should be noted that the list of users is synchronized from a central database, and if a user has no email address, this will be synchronized to the Matchmaking database without having one. Furthermore, the Matchmaking button in the Marketplace returns to the Matchmaking tool.

The **efficiency of use** can be negatively affected by some latency-related slowdowns given that the tool is only hosted in UK. However, in most situations the speed is not excessively slow for the users. The user's profile can be checked before adding them to the team, and all the user's details are available in their profile. Additionally, before finalizing the team, the user can view the email addresses of the selected users.

Furthermore, some problems related to the **recognition of errors** were not directly related to the Matchmaking tool, so this was derived to the corresponding one.
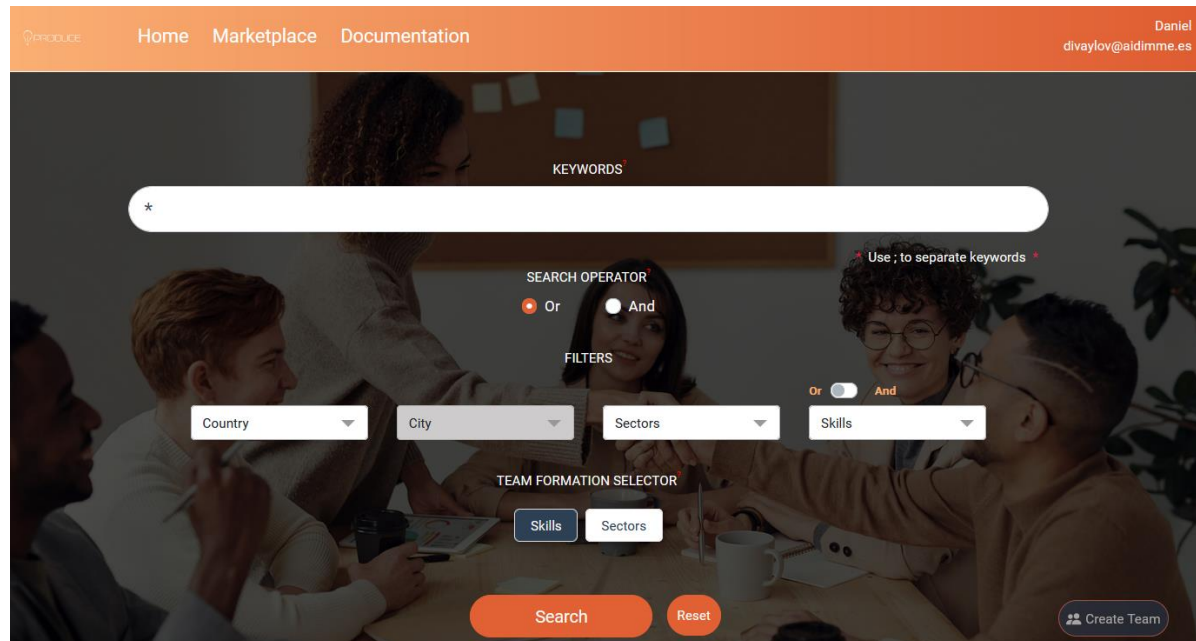

Figure 13 New design of the Matchmaking frontend

The Figure 13 above shows the new aspect of the Matchmaking frontend, what includes a button to reset the content of filters and text fields, a new navigation bar, filtering, tooltips, and a documentation section.

Regarding the **documentation**, besides the videos available and the tool's functionalities explained in the corresponding deliverables, the Matchmaking tool has incorporated tooltips to clarify the functionality of the tool, and a separated page for help and documentation with pictures has been added.

The problem found when the user clicks in the 'Matchmake' option from the Marketplace has been addressed: a link to navigate to the Marketplace from the Matchmaking tool will be added, and the user can also click the "Back" button to return to the Marketplace.

AR (Mobile App Client)

The **user control** could not be improved, so the users still need to logout and login every time they want to notice updates in the products. The **error prevention** also could not be properly addressed, so the there is no manual nor documentation associated with the contacts.

About the **recognition** topic, the documentation videos do not have any speech to explain the steps to be followed by the user through the tool, no information about the different tabs is available in such documentation, and the search option – which is valuable considering the potential number of products to be published the platform – is not available.

Regarding the **efficiency**, no information tab has been added and the setting tab – which can be considered as redundant – was not removed, and the **recognition** topic was not improved so the association between products and 3D models available for those products is not clearly represented. Finally, the **documentation** was not addressed so the App does not present links to any user manual or guidelines. Some videos with text content are available in the iPRODUCE website, and some text with pictures in the OpIS platform.

In short, the AR Mobile App Client has not improved from the last version evaluated in the Final Round of the heuristics assessment.

VR (VR Client)

The **visibility** issue – which for this tool mainly covered the long loading time – could not be addressed due to technical limitations, and there was no research time available for the optimization of this aspect, also considering other priorities to be considered. Just a very fast Internet connection in the user side could cover this issue. Besides this, no logout option is available. Therefore, many professionals in 3D modelling claimed the lack of usability of the tool in most cases.

Regarding the **matching** between the system and the real world, the content in contact and settings remained empty and the information available is just available in the project website. This information does not explain the tabs of the tool and how to use them, and the 'configurator' and 'my design' concepts are not clear, and the videos do not have any speech.

About the **user control**, some users experimented problems with the use through shortcuts. The developers consider that keyboard shortcuts remain the best way to perform actions in the 'Design Mode', while having control of the cursor in the first-person camera view which this mode uses. The point is that, for people who is not so familiar with videogames, the use of the tool is not so easy and intuitive. At least, some information – not present at the time of this writing – about the controls could be added.

The **error prevention** aspect was related to the interactions through the tool, and the management of notifications when some mistake is done by the user, which were quite confusing to some users. From the technical side it was reported that these annotations can be deleted by the X marks, assuming that it is understandable that this is not clear to many users. In any case, help text was added at the top of the screen to show information about how to perform actions in the tool.

Regarding **recognition** topic, users reported that there is no information about the association between products and 3D models, so users could not know if a particular 3D model associated with a product is available to be processed through the tool. At the time of this writing, there is no information to be aware if a product has some 3D model associated or none. Also, there is no reference in the 'configurator' section in order to know if the user is addressing the original product, or one created by a team.

Finally, the **documentation** was not addressed so the App does not present links to any user manual or guidelines. Some videos with text content are available in the iPRODUCE website, and some text with pictures in the OpIS platform.

All in all, the VR client remains as the previous AR tool, so this has not improved from the last version evaluated in the Final Round of the heuristics assessment.

Mobile App for Social Media

Most issues related to the **user control** are addressed through the documentation (i.e.: the user can switch between questionnaires through the burger button available from the first screen).

Regarding **error prevention**, it should be clarified that the replies introduced in the questionnaires are cleared of the user goes back to the "Home" section because the tool does not save intermediate results. Indeed, the surveys must be short, and the expected time up front is displayed on purpose. The search option was considered as a good function to made available but not considered as a formal requirement.

The **flexibility** has been considered as well addressed so the nature of this tool does not require specific customisation options, and problems related to the **recognition of errors** not were related to the mobile app and they have been derived to the corresponding components.

Finally, **documentation** can be found just through videos and deliverables D4.6 and D6.3. Further guidelines can be found in the OpIS platform in the same section than the Marketplace.

Agile Data Analytics and Visualization Suite

Lately, this tool got significant improvements. Regarding the **user control**, the logout button was moved to the top right menu. It should be noted that the problem related to the empty surveys page does not depend on the Agile Data Analytics tool so was derived to the corresponding partners.

About the **error prevention**, the occurrence of empty graphs is rare and temporary, and the hidden menu on the graphs has been made always visible in the last version.

Even though the search functionality could not be implemented, the **recognition of errors** has been addressed by adding popups on the most "hard-to-understand" graphs, to better describe its usefulness, and how to interact/analyse them.

Regarding the **efficiency of use**, a contact form has been included to contact the technical team in charge of the implementation of the tool, along with the general OpIS platform contact page. Moreover, the size of the graphs was updated to make them clearer for users.

The **recognition of errors** topic could not be addressed, but the **documentation** one was solved through the implementation of popups as previously indicated.
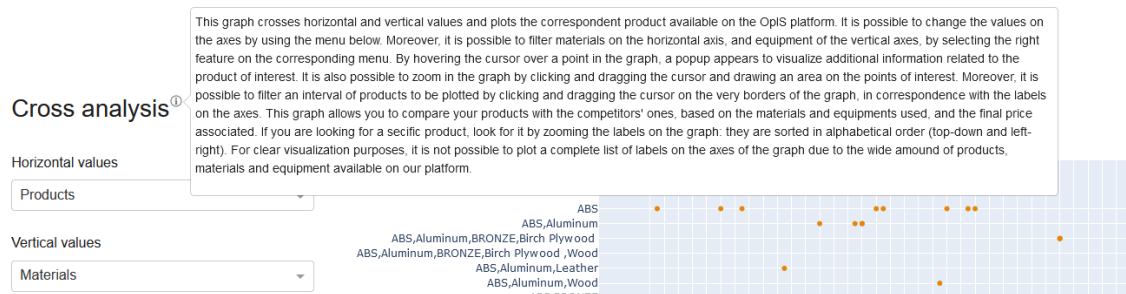

Figure 14 Detail of explanatory popups added to the Agile Data Analytics tool

The Figure 14 above shows a detail of the message popups added to clarify the meaning of those graphs which are particularly hard to understand at first sight.

Finally, although the **documentation** about how to use the tool does not include pictures, this is ready and accessible directly from the tool.

Video Intelligence

As commented previously in the GDP tool section,usability requests were integrated as Software Requirements Specifications for the coming versions after March 2023. Besides this, there is documentation available through videos, but they are not accessible from the tool nor the OpIS platform. They are published in the iPRODUCE project website.

CMDF Training Flow

The **matching** between system and the real world was scored a bit low by the users, so they considered that it is hard for them to determine if the information is well structured in the tool. However, it should be noted that the professional-designer purposed nature of the tool probably makes it hard for non-professional use, and this is the way that it has been conceived. This also applies to the overall **aesthetic and design** topic. Regarding **recognition of errors**, some users still had some issues related to the need of inserting a name for the elements, but the addition of default names in the various fields was dismissed, so the name of each element can be changed by hand and therefore the application works as expected. Finally, the **documentation** topic has not been significantly addressed, so there is just some information available in the iPRODUCE project website.

CMDF Training View

The **flexibility** aspect was low rated by the end users because they could not find customization options in the tool and found some loading problems. It should be notices that this application is served as a companion to the CMDF Flow app. Therefore, first a user needs to use the CMDF Flow app to create a procedure, and then export it appropriately so it can be consumed and viewed by the CMDF View. Besides this, the optimization of the application is indeed an issue, and various constraints, such as the user's device and particular procedure contents have a negative impact in the loading times. The **recognition of errors** is also related to the previous issue. In any case, no guide or information about how to export the process from flow to view has been made available to the users. Finally, regarding **documentation**, the requirement for the 'Digital Twin' button was to redirect the user to the Digital Twin repository found in GitHub and, therefore, no more documentation is available apart from this. Regarding the **documentation** topic, as in the previous cMDF Flow tool, this has not meaningfully improved, so just some information can be found in the iPRODUCE project website.

Process Automation Tool

It should be reminded that this tool has been experimented only by AIDIMME, in the scope of the Spanish cMDF and, at the time of writing of D9.3, the new version of the Process Automation Tool was not released, so the final round of the heuristics evaluation of this tool could not be performed. However, a new version of the tool was released some weeks before the release of D9.3, addressing many of the comments detected by the users during the heuristic evaluation.

In the new version of the Process Automation Tool, the **error prevention** issue has been addressed, so the mandatory fields are indicated. If they are not completed, they are automatically highlighted in red colour including a text indicating that the filed must be fulfilled.

Regarding the **recognition of elements**, it should be noted that the search is not something particularly needed to make a satisfactory use of the tool. Also, the overall performance and **efficiency of use** has been significantly improved, and the tool runs faster than in the previous version.

The **recognition of errors** has also been improved, so in the new version red alerts containing information about the errors are prompted to the user when some problem occurs.

Furthermore, regardless of the availability of guidelines or documentation, the process to operate with the tool is easier to understand and complete by the users in the new version of the Process Automation Tool, and a diagram always indicates the step where the user is located.

Indeed, the tool has changed implementing several important features. The process becomes simpler, and the iterations are much clearer. The diagram of the process can be consulted, and the user can watch at which point the user is currently working on.

All the tasks are assigned to a user automatically, but the user assignment can be easily changed by hand, which is great because a professional user not available at a given moment can be selected. In the new version, the design brief presents an improved structure and a prototyping document. Texts in red are displayed to indicate the mandatory fields, and the overall performance has improved a lot. The Figure 15 below depicts an example of a model diagram that can be processed by the tool.
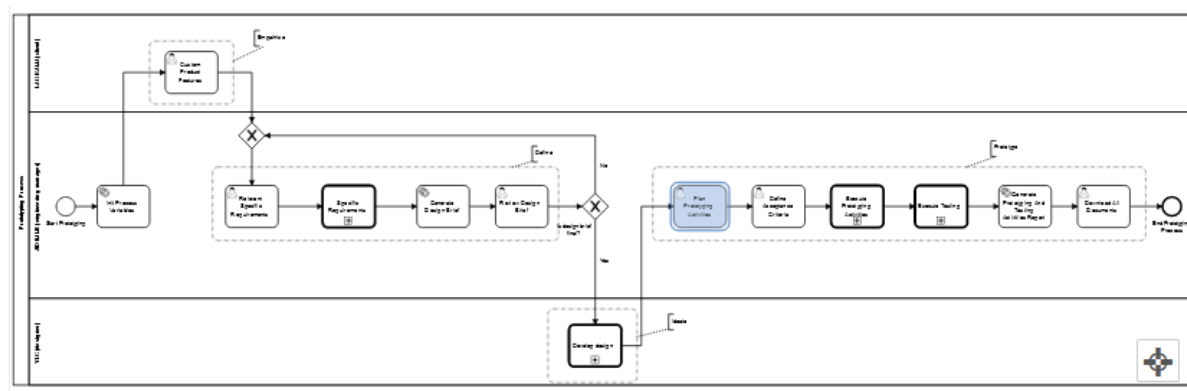

Figure 15 Diagram of working process

Regarding the **documentation** topic, some information can be found but not inside the tool nor the OpIS platform, but the iPRODUCE project website.

Management of new functionalities and bugs

From May 2022, a spreadsheet to report the need for new functionalities by the end users was created. Through this online document, the developers of the different tools (organized by tabs in the spreadsheet) could also add their replies to the comments made by the users. This approach meant a very useful way to track and manage the improvements made to the different tools of the OpIS platform, facilitating the progressive testing and feedback reporting.

Among the new functionalities implemented during this process, it should be highlighted the ones from the **Marketplace**, that included additional files to the user profile, such as the Country, City and Sector attributes, including an indication about the cMDF nationality.

The Marketplace has also incorporated references to additional social media networks in the user profile, such as *LinkedIn* and *Behance*, a social network much oriented to designers, where users can publish their portfolios.

In addition, regarding to the Marketplace, the name of the user was made always visible so this could be changed on demand. Furthermore, dropdowns to select materials and machinery were implemented to avoid free texts for those fields, and longer text descriptions allowed. An option to navigate to the Analytics tool was included to inspect the overall analytics and the surveys.

It is also possible to find by equipment in Marketplace, and not only in the fablabs.io website as initially, and the "Role" attribute was removed from the Marketplace, so the users often does not know it. The date of the creation of the teams was added, as well as a field to identify the

Company/FabLab name that the user belongs to. Macro categories of equipment were added to the company profile, including tags, and the capability to search products by date of publication was implemented as well.

It was decided to add to the dashboard of the cMDF ("manage community") the possibility of accepting or rejecting a member who wants to join. The option is depicted in the screenshot of Figure 16 below.
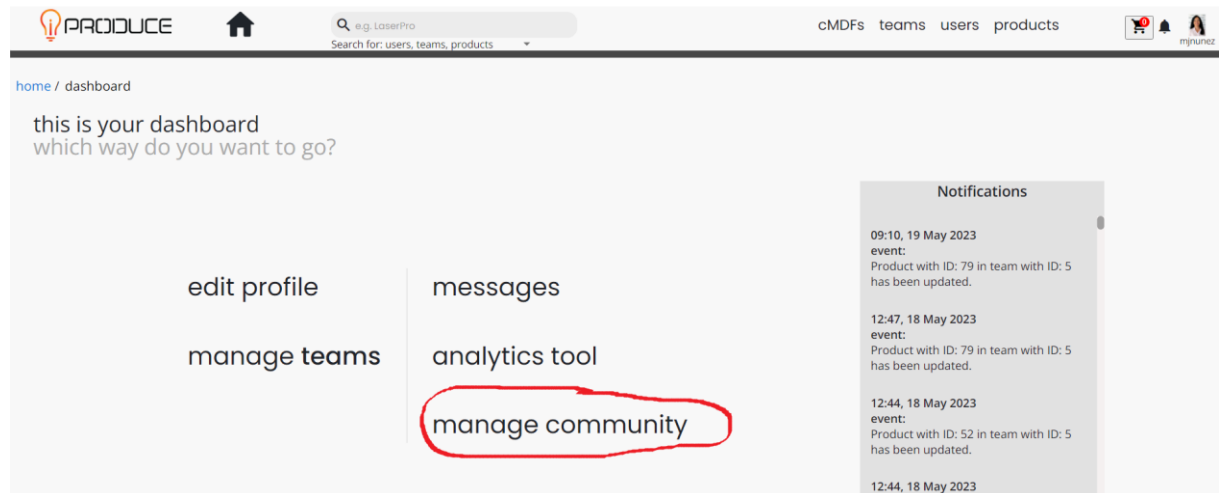

Figure 16 Manage community option to manage the acceptance of new users in the Marketplace

In this way, the administrator, once receives a notification from the new user, can accept her/him in the Community, ensuring that the community is made up of real users.
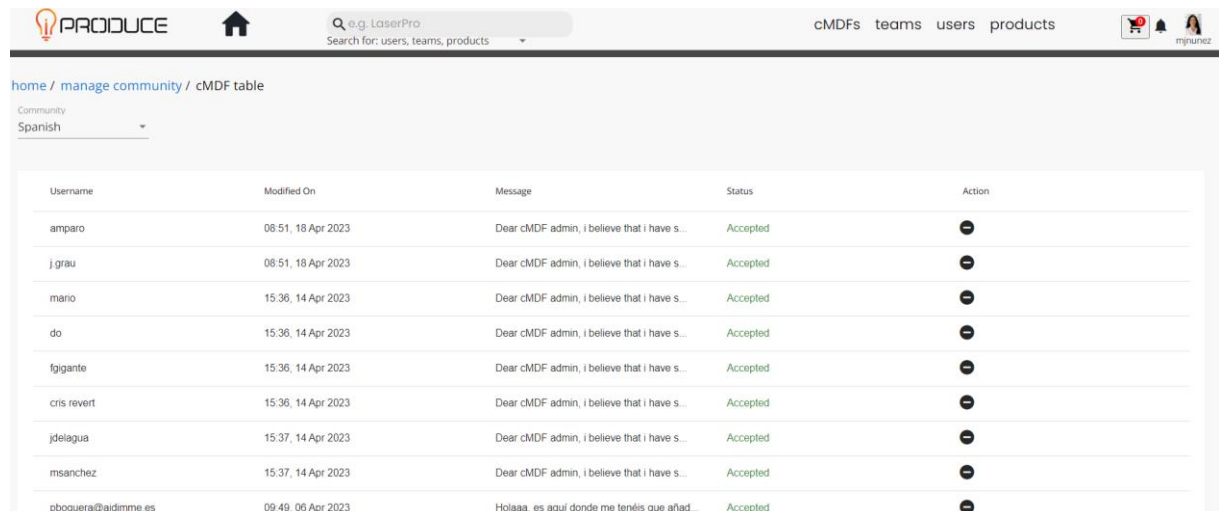

Figure 17 Detail of users' acceptance for community management in the Marketplace

The Figure 17 above shows the list of users that have requested access to the Marketplace and the status of the corresponding acceptance.

Furthermore, the attributes added to the Marketplace have been considered in the **Matchmaking**, so the search can be improved by using the new fields added to the user profile, such as the Country, Location, Skills, and Sector.

Besides this, the **Agile Data Analytics Tool and Visualization Suite** was evolved providing the visualization of the questionnaires created by the Marketplace and fulfilled through the **Mobile App for social media**.

The Figure 18 below shows an excerpt of the file used to manage the reporting of new functionalities.

	A	B	C	D	E	Status
1	#	where	New Functionality: thank you for your ideas: we will be collecting your suggestions here and make the final decision in a future version	reported by	date (of reporting)	possib
14	#7	/landing-page	For ALL collaborative co-design product needed to have a common CHAT for saving all the comments from the Team´s users while using the AR/VR/GDP tools (it could be added to the "message log"	Maria (AID)	11/05/22	
15			reply: we can only address features for the Marketplace - we have no access or info on what is happening in the rest of the tools			
16	#8	edit-profile	Able to Join a COMMUNITY (cMDF), otherwise the community will never grow up, only as individuals or teams	Maria (AID)	13/05/22	
17			reply: community is wip; community is to be responsible to add members; in current version admin = platform admin (ED)			
18	#8		Multilanguage (change language, not only in English)	Maria (AID)	17/05/22	
19			reply: not foreseen within iproduce			
20	#9	/users-list	Filtering type of user in some way, at least alphabetical order...)	Maria (AID)	17/05/22	
21			reply: lets discuss this: in what way? (i don't see how 'alphabetical helps'), we not use 'search' to do this?			
22	#10	/??	Offering kind of Alert to announce specific "demand" (i.e.: "I need urgent help in co-designing a headboard with light materials")	Maria (AID)	17/05/22	
23			reply: not foreseen within iproduce: requirements need to be clarified on the business level (does this mean that i as a user am			
24	#11	/user profile	After a team creation you can rate a user from the team positive/negative and the average of this user must be visible by the	Maria (AID)	17/05/22	
25			reply: this assumes a business-to-business mindset; we approached the co-creation idea as a incentivation to push consumers			
26	#12	/user profile	needed to add LinkedIn and BEHANCE (designers´portfolio)	Maria (AID)	17/05/22	
27			reply: ok			
28	#13	manage teams	When you have created a product as a user, is it possible to transfer it in teams? Because we have created again the products, in order to be used in teams	Zoli (CERTH) & Dimitris (Aidplex)	17/06/22	
29			reply: ok			
30	#14	manage	Not able to select more than one sector in profile	Maria (AID)	22/02/23	
31			reply:			
32	#15	manage	The notification (alarm on the top with "0") must be updated even if you are log in, not only when you log in or press F5.	Daniel	22/02/23	
33			reply:			
34	#16	manage	You are not aware of any notification regarding a product in a Team, in the message log, if you don´t enter in that	Daniel	22/02/23	
35			reply:			
36	#17	manage	Change the information regarding selection of materials or tools/machinery as no more is separated by semi-colons...	Maria (AID)	22/02/23	
37			reply:			
38	#18	manage	Upload file: how do you know only ONE file you can upload, and no more. No sense! You can upload a word, CAD file,	Daniel	22/02/23	
39			reply:			
40	#19	manage	Change the information regarding selection of materials or tools/machinery as no more is separated by semi-colons...	Daniel	22/02/23	

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Figure 18 Excerpt of the spreadsheet created to manage bugs and problems found in the use of the iPRODUCE tools

Moreover, from January 2022, a spreadsheet for the reporting of problems and bugs related to the use of the OpIS platform tool was created. Following a similar approach to the reporting of new functionalities, the bugs spreadsheet also manages specific tabs for each tool, and the technical partners can reply to the users' comments, asking for more information about the scope of the error, or indicating that the problem detected by the user was successfully solved. The Figure 19 below shows the spreadsheet file used to manage the bugs and detected problems found during the use of the tools.

	A	B	C	D	E
1	#	where	what is the problem	reporter	date
24	#23	Landig page 1	Point 2 Products are drawn from the database (create some new products for your cMDF and we'll display them here) Aidimme created 2 preoducts and can not spot any of them.	Maria & Daniel	24/01/22
25	#24		reply: the problem should have been fixed moving towards the meeting with the PO (all products are displayed under the 'products' tab) Action: AIDIME to check	themis	28/04/22
26	#25	landing page - 2	Information : "Devoted to the presentation of the cMDFs can you write a few words describing who you are and what you develop? add an image to make it more visual? do you want to add a link to another page for more info?" Can not change the info of "Visit our cmdfs" clicking on the divs.	Maria & Daniel	24/01/22
27	#26		reply: the description of the cmdfs is updated in the current version by the platform admin (ED); as soon as we have more info from all cmdfs we can update the functionality if needed Action: all cmdfs to provide their description and suggest how they want to administer the description; (if cmdfs want to administer on their own, OpIS will need to add the user role of 'community admin') -> ICE & CERTH	themis	28/01/22
28	#27	Landing page -3	Dashboard option should appear in the tool bar, not in the profile	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
29	#28		reply: the toolbar provides access to material in the entire marketplace, the dropdown menu under the avatar provides access to user-related features (separates thematically the access points) - request not considered for update - please provide a design if you have a more substantial (bigger) intervention in mind Action: no action to be taken	themis	28/04/22
30	#29	Dashboard	When you open the dashboard, and select one of the provided options (e.g. edit profile) there is no option of a button/ arrow in order to go back	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
31	#30		reply: the home button brings you to the landing page and you can go to the dashboard via the dropdown menu under avatar Action: no action to be taken	themis	28/04/22
32	#31	Edit profile	In the Avatar pic, should be useful to add information: "Drag and drop an image". And also, should be useful to propose some of the acceptable file formats (e.g. jpeg, etc). In addition, when the picture is loaded it appears as a background and the the "Avatar pic" appears on front of the image	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
33	#32		reply: do not understand how this information should be displayed to the user (can you propose a way?); cannot replicate problem w/ 'avatar pic' Action: no action to be taken	themis	28/04/22
34	#33	Add a product: Describe	In Main Image, should be useful to add information: "Drag and drop an image". And also, should be useful to propose some of the acceptable file formats (e.g. jpeg, etc).	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
35	#34		reply: done Action: no action	themis	28/04/22
36	#35	Add a product: Describe	In Upload File option, should be useful to propose some of the acceptable file formats (e.g. obj, stl, etc).	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
37	#36		reply: the marketplace makes no discrimination Action: no action taken	themis	28/04/22
38	#37	Add a product: Describe	Rejection of big files in Upload File option	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
39	#38		reply: restriction comes from the implementation of the db and is there for technical reasons Action: users to indicate upload file limit	themis	28/04/22
40	#39	Add a product: Customize	Update Product button should be placed after completing "options for", or should be updated automatically.	Zoli (CERTH) & Dimitris (Aidplex)	02/01/22
41			reply: the 'update product' refers to the entire section that is devoted to the product description (all tabs); this is why it is placed in the 'Mandatories' section, where it is always visible; automatic update is difficult, because we are handling large images in the 'describe' page		

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Figure 19 Excerpt of the spreadsheet created to manage bugs and problems found in the use of the iPRODUCE tools