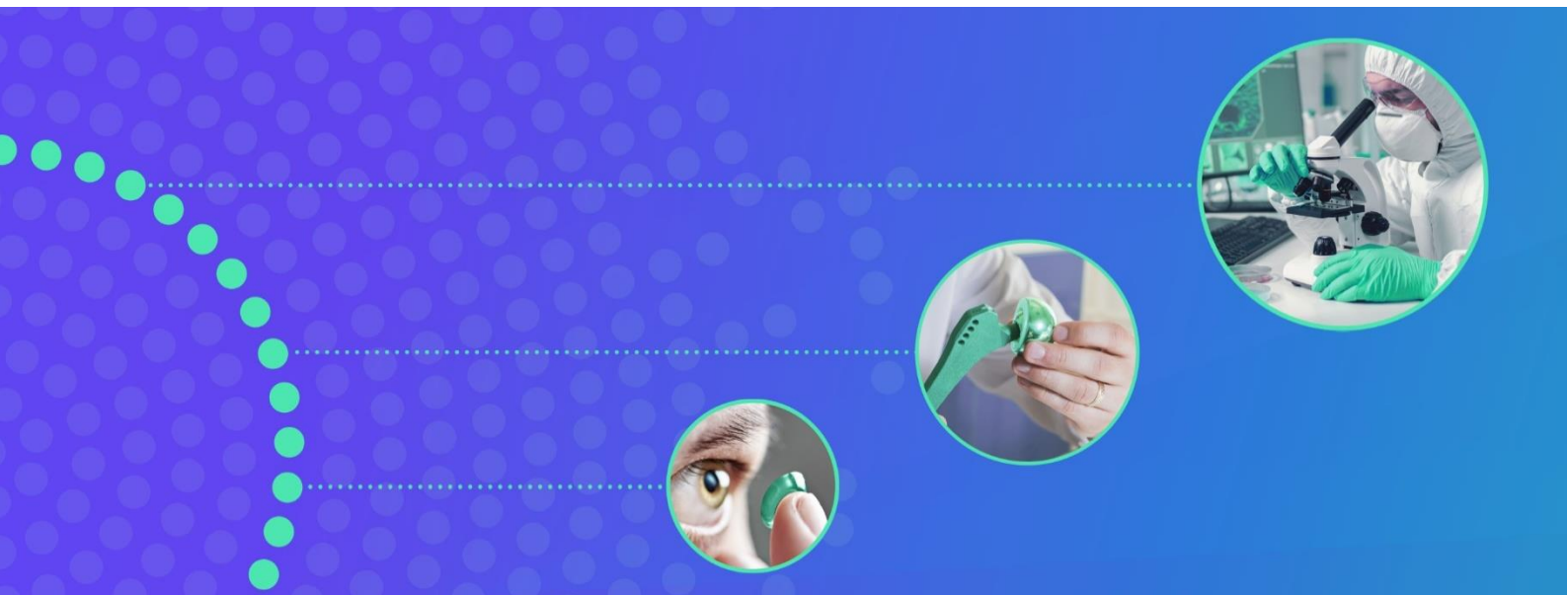




MINDS & SPARKS



BIOMATDB

ADVANCED DATABASE FOR BIOMATERIALS WITH DATA ANALYSIS AND VISUALISATION TOOLS EXTENDED BY A MARKETPLACE WITH DIGITAL ADVISORS

Grant Agreement: 101058779

D5.1 DEM Demonstration plan and test system (Additional Document)

DISCLAIMER: While the BIOMATDB Demonstration Manual represents the actual deliverable, this document is an additional, public report intended to describe the development and creation of the Demonstration Manuals.



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Authors	Clémence Foltz (CLUSTER) Fábio Grilo (CEC/CCIC) Tilman Kerl (SYNYO) Jakob Seper (SYNYO) Jan Rodríguez Miret (BSC) Miguel Rodríguez Ortega (BSC) Judith Rosell (BSC) Athina Samara (UIO) Celine Rabé (M&S) Roland Reiter (M&S)
Contributors	Nicole Ticchi (CLUSTER) Sauro Vicini (CLUSTER)
Reviewers	Violeta Heinze (M&S)

Executive Summary

BIOMATDB focuses on the creation of a game-changing, publicly available advanced database for biomaterials and a web-information driven biomaterial marketplace. By deploying these digital solutions, BIOMATDB aims at revolutionising the field of biomaterials. The novel technical systems and data processing methods will be tested within existing open innovation testbeds and validation groups. As described in the project proposal, an intuitive demonstration manual will support and accompany the use of the database and marketplace to arm partners with a step-by-step decision-support handbook. The BIOMATDB Demonstration Manual is a comprehensive guide of the structure, framework, demonstration and validation approach, leading to the initial testing and training. The document aims to clarify goals, outline the timeline, set the groundwork of the demonstration, and support partners involved, including a risk assessment and troubleshooting section.

We, thus, present here the Path to developing the First Version of the **BIOMATDB Demonstration Manual**. While the actual deliverable contains a detailed demonstration plan including the overall test design in terms of pilot and test questions, timing, applied methods, guidelines for reporting of recommendations and improvements, and scenarios for testing, this document is an **Additional Report** intended to give an overview of the demonstration plan and progress. Divided in 5 chapters the reader is introduced to the general demonstration approach and overall framework underlying the demonstration phase (1), an overview of the envisioned testing (2), and training activities (3), planned demonstrations (4), potential risks and mitigation plans (5). The document describes in more granularity and detail the **Demonstration Plan (A to D)**. In brief in **A**, the primary focus is on the administration panels, to validate their functionality, usability, and security, whereas the goal of **B**, via data processing and intelligence unit, is to ensure efficient and accurate processing of biomaterial data and intelligence generation. **C** revolves around Biomaterial Database frontend components to validate the user interface, data presentation, and search functionalities, whereas demo **D**, focuses on the Biomaterial Marketplace frontend, primarily to validate the user interface and search functionalities. The **Envisioned Activities** provide tentative context, including the role of the Data Processing & Intelligence Unit, Mobilization measures, Trainers and User involvement, designed to support the successful deployment of the webtools. This User-Centred Demonstration and Validation Approach highlights the webtools capabilities, and path to validating their performance.

Highlighting the importance of rigorous testing, training and validation to ensure end-point reliability and effectiveness, the document delineates the **critical aspects of the project deliverable**, providing **insight on the framework of the webtools, and the guidelines for users**, and the **elements, core design and architecture of the database and marketplace webtools**, are outlined to define the method to source future capabilities, functionalities, and data flow. Mobilising partners for the initial testing and training, it contains **information on the initial testing phase**, including envisioned test scenarios and procedures. Additionally, it outlines the **training agenda** designed to familiarise users with the webtools' features and functionalities. Optimally **addressing the needs of the target groups**, using criteria of previous surveys, the user-centric approach ensures that the webtools meet the diverse requirements of the different types of users.

An essential resource for all involved in the development and deployment of these innovative webtool solutions, this document illustrates the BIOMATDB commitment to meet and exceed end-users' expectations.

Contents

Executive Summary	4
1 Introduction.....	8
1.1 Overview.....	8
1.2 Relation to other tasks and deliverables - Overview	8
1.3 Past BIOMATDB tasks and deliverables and relation of D5.1 to future goals.....	8
1.4 Structure of the deliverable	9
2 Demonstration Framework and Approach	10
2.1 The aim of the User-centric Approach	10
2.2 Demonstration and Validation Plan	11
2.3 Deployment in a Test Environment.....	12
3 Testing	13
3.1 Methods and specifications	13
3.2 Testing tools and materials	14
3.3 Testing guidelines and recommendations	14
4 Manual: Training methods, tools, materials and handbooks.....	16
4.1 Training methods and specifications.....	16
4.2 Training guidelines and recommendations.....	17
5 Manual: Demonstration plan and activities.....	19
5.1 Demonstration Plan.....	19
6 Risk Assessment and Mitigation Plans	33
6.1 Process risks	33
6.2 People risks.....	33
7 Conclusions.....	36
References.....	37
Websites.....	37

Figures

Figure 1. The main steps of the human-centred design approach. Adapted from ISO, 2010 [2].	10
Figure 2. The human-centred design approach taken by BIOMATDB.	11
Figure 3. Trello boards for Biomaterial Database and Biomaterial Marketplace	15
Figure 4. A Demonstration Manual mock-up screenshot	16
Figure 5. Screenshot of biomaterial database on Elasticsearch	21
Figure 6. Prodigy screenshot of 'Human' MeSH term classification	22
Figure 7. Model evaluation metrics and confusion matrix examples for content classification	23
Figure 8. Detailed timeline for the roll-out of the demonstration C (database front-end).	24
Figure 9. Examples of a qualitative interview (left), and a short feedback form (right).	26

Tables

Table 1. D5.1 Input from other tasks and deliverables	9
Table 2. D5.1 Output for other tasks and deliverables	9
Table 3. Overview of the four BIOMATDB demonstrations	12
Table 4. Coverage of the BIOMATDB solutions by the identified stakeholders.	12
Table 5. Potential process risks identified and proposed mitigation measures	33
Table 6. Potential people risks identified and proposed mitigation measures.	34

Acronyms & Abbreviations

Term	Description
GDPR	General Data Protection Regulation
KB	Knowledge Basis
KPI	Key Performance Indicator
M	Month
WP	Work Package

1 Introduction

1.1 Overview

This demonstrator delivers a comprehensive overview of the overall framework and approaches that will be used for the demonstration of the two solutions that are being developed by the BIOMATDB consortium: a biomaterials database and a biomaterials marketplace. It includes the tasks, timing, methods and tools that the consortium is planning to use to roll-out the training and testing of the BIOMATDB webtools.

The deliverable also provides a sneak preview, in the shape of screenshots, of the demonstration manual that the consortium has developed. In addition, this document will serve as a handbook or instructional guide with detailed information and instructions for partners on how and when to prepare, train, test, report and analyse the findings.

1.2 Relation to other tasks and deliverables - Overview

1.2.1 Based on

This Deliverable is founded on the Consortium's previous work that explored the needs and expectations of stakeholder and received insights from the use-cases drive surveys and meta-use cases' investigation. The work builds upon the expertise and interdisciplinary foundation, and the innovative concepts of digital advisors for the development of the Advanced Biomaterial Database and Marketplace.

Substantial progress was achieved during Phase I of the Data Processing Methods and Tools, and Web Application for the Marketplace. Furthermore, the detailed specifications have enabled a comprehensive synthesis of unique knowledge and novel resources. All these form the basis for the development and improvement of the web platforms, ensuring that they will align with the evolving needs and expectations of Target Users and Stakeholders.

1.2.2 Basis of

This phase serves as the cornerstone for several significant milestones in BIOMATDB project development. First and foremost, it will provide the necessary groundwork for an updated stakeholder survey, enabling us to gain fresh insights and refine efficiency but also reach-out and dissemination approaches. Additionally, it lays the foundation for the next stage of the Database and Marketplace application, encompassing both frontend and backend improvements in Phase 2. This part enables the creation of an online knowledge base (KB) that will house comprehensive manuals, frequently asked questions (FAQs), and instructional screencast video tutorials. As we progress beyond this stage, we will embark on the creation of the Demonstration and Validation Reports for Phase 1 and Phase 2, documenting efficiency and accuracy of these innovative solutions.

1.3 Past BIOMATDB tasks and deliverables and relation of D5.1 to future goals.

Receives inputs from D2.2, D2.3, D3.1 and D3.2 whereas it provides outputs to D2.4, D4.3, D4.5, D5.2 and D5.3, as shown in Tables 1 & 2.

Receives inputs from:**Table 1.** D5.1 Input from other tasks and deliverables

Deliverable	Due Date	Input for D5.1
D2.2	31.01.2023	Requirements of stakeholders and use cases from survey
D2.3	31.01.2023	Meta Use Cases, Requirements and Label Specification Report
D3.1	28.02.2023	Advanced biomaterial database, data tools, marketplace and digital advisors' concept
D3.2	31.05.2023	Database, Data Processing Methods, Tools and Web Application Marketplace and Specifications (Phase 1)

Provides outputs to:**Table 2.** D5.1 Output for other tasks and deliverables

Deliverable	Due Date	Output from D5.1
D2.4	31.05.2024	Updated stakeholder survey
D4.3	31.08.2024	Database and marketplace application frontend and backend (Phase 2)
D4.5	31.10.2024	Online knowledge base (KB) with manuals, FAQ, and screencast video tutorials

1.4 Structure of the deliverable

The Demonstration Manual is the first draft of the handbook that will facilitate user involvement with the digital tools and it is structured in 5 chapters:

- **Chapter 1** aims to introduce the reader to the general demonstration approach that the consortium will adopt and presents the overall framework underlying the whole demonstration phase;
- **Chapter 2** provides an overview of the methods and tools to carry out the testing activities;
- **Chapter 3** addresses the methods and tools that will be used to execute the training activities;
- **Chapter 4** addresses in more detail and granularity the context of the four planned demonstrations which have been planned. In addition, project progress monitoring and feedback consideration and ensuing customization are described;
- **Chapter 5** finally identifies and enlists the potential risks that could occur during the demonstration phase. Mitigation measures that could be applied by different consortium partners and are brought forward. Although the project is proceeding at the expected timeline, any negative repercussions on the timely and efficient delivery of the tasks has been listed.
- A brief set of concluding remarks summarise the concept and methods envisaged, under the Concluding Section of the Manual.

2 Demonstration Framework and Approach

2.1 The aim of the User-centric Approach

In today's rapidly evolving digital world, it is essential to understand unmet needs and prioritise the expectations of end-users to ensure the success of webtools. To this end, the consortium is applying the user-centric approach, so that the target audience of the database and marketplace can be attracted, motivated, convinced and retained. This aims to ensure early stage involvement, retained until the demonstration and validation phase that the digital solutions are functional and sustainable. **The design solutions are customised**, that is they are **based on the feedback** received **from** the users during the **evaluation stage** and it is adjusted and refined **to ensure that the final product meets user needs and requirements**. The active involvement of customers at all stages throughout the design process, and the contribution from a multi- and inter-disciplinary team that boasts a diversity of skills and perspectives, are therefore crucial for the successful implementation of the human-centred design activities.

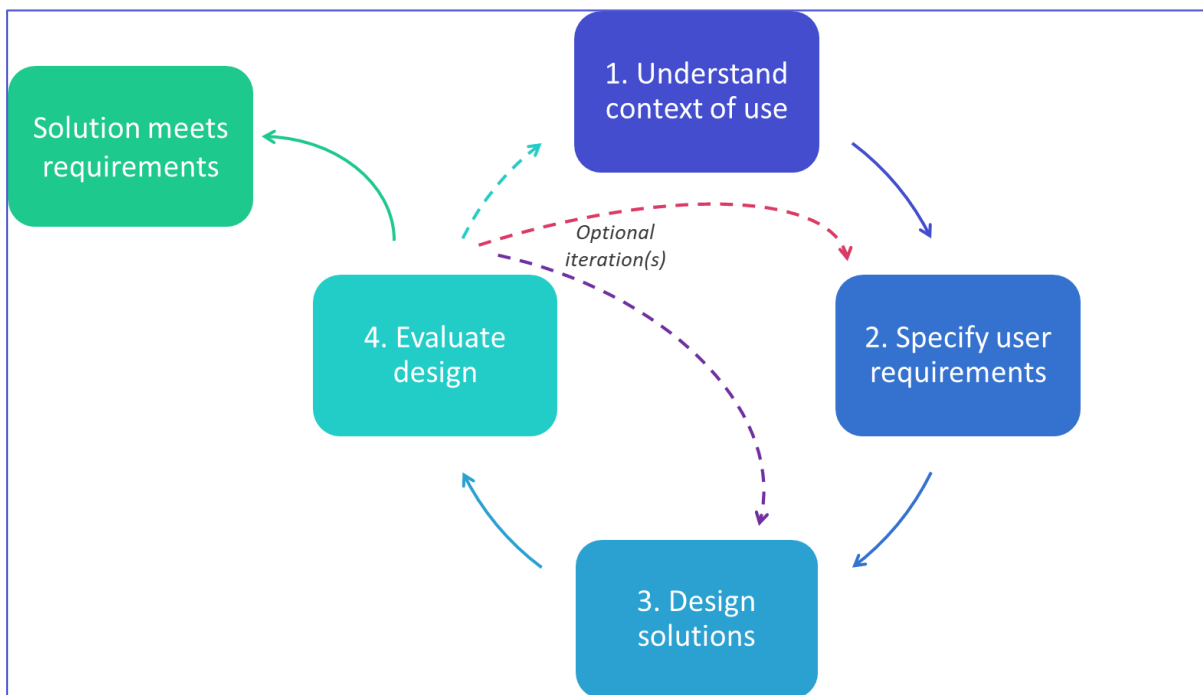


Figure 1. The main steps of the human-centred design approach. Adapted from ISO, 2010 [2].

BIOMATDB's efforts have employed the user-centric design, and the consortium has identified 5 different groups of stakeholders that are potential future users of the two core applications, whose needs and requirements should be considered:

- **Researchers** (academia, research institutions, scientific communities)
- **Demanders** (medical and hospital organisations, health professionals, medical procurers, patients)
- **Suppliers** (SMEs, start-ups, industry)
- **Enablers** (societies, associations, networks, foundations)
- **Investors/policy makers** (governmental and regulatory authorities, public bodies, investors)

Taking these under consideration, these were then utilised as the starting point for the technical teams to build the two BIOMATDB digital solutions. To maximise partners capacity and resources, and to monitor Target users needs and demands, BIOMATDB has dedicated a whole work package (*WP5 / DEMONSTRATE: Deployment, Validation, User Tests, Training Activities, Feedback Gathering, and Optimisation Requests*) to the demonstration and validation of the digital solutions. This work package will monitor the development of and provide the tools that they serve as user guidelines and training manual for the end users.

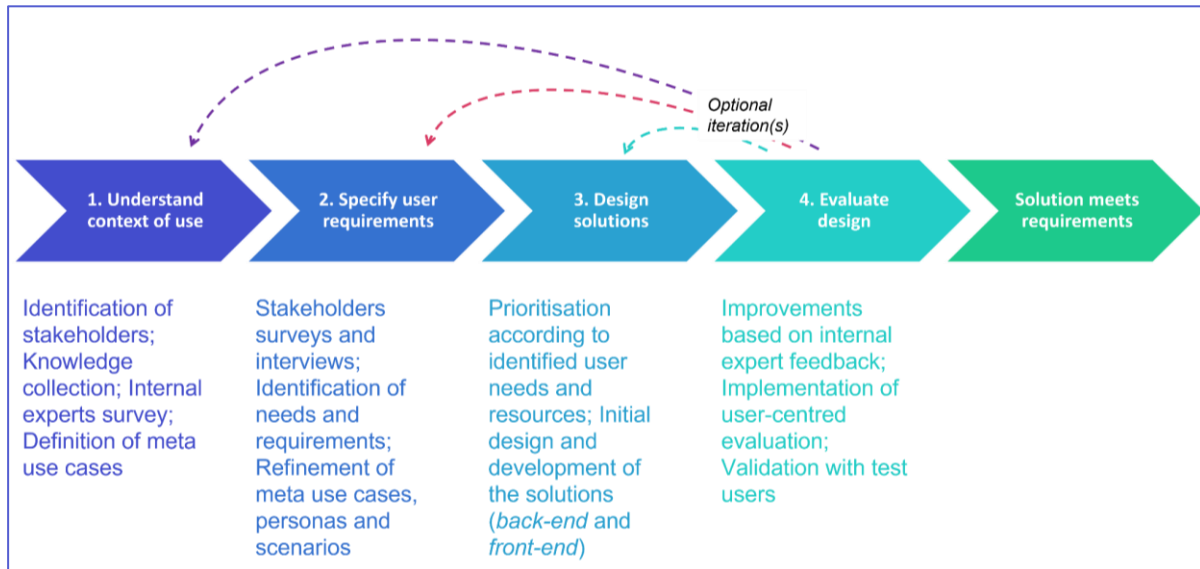


Figure 2. The human-centred design approach taken by BIOMATDB.

Thus, after the initial design is finalised, an internal validation by consortium experts will assess usability, performance, and functionality. This feedback will highlight strengths, weaknesses, and areas for refinement, based on importance and technical feasibility.

The second version will undergo iterative evaluation and design cycles, guided by external end-users. Aided by different BIOMATDB partners across Europe the tools will be tested, to compile feedback on user experience, interface, and functionality. Test users from partner networks and stakeholders have been identified in earlier phases and feedback tools like workshops, webinars, surveys, and interviews will be employed. Response analysis will help identify user patterns, feature requests, bugs, and common issues for prioritized incorporation into the iterative design process, further enhancing the solutions.

2.2 Demonstration and Validation Plan

To ensure that the final developed BIOMATDB technical solutions (database and marketplace) will fulfil the demands and identified requirements of the relevant user groups, an extensive demonstration, validation and testing phase will be performed, running four different, parallel but related phases as shown in Table 3:

Table 3. Overview of the four BIOMATDB demonstrations

Name	Objective	Focus
Demonstration A	Run data integration and administration validations, evaluations, admin panel usability tests and collect feedback	Back-end
Demonstration B	Run database performance and processing validations, evaluations, and collect test protocols	Back-end
Demonstration C	Run database and data analysis tool end user tests, evaluations, training activities and collect user feedback on usability and usefulness	Front-end
Demonstration D	Run marketplace and advisor application validations, evaluations, training activities and collect user feedback on the usability and usefulness and the biocompatibility label	Front-end

The first two Demonstrations A and B, that concern the core technical components (Admin Panels and Data Processing), will be the first ones to be rolled out. These demonstrations will mainly rely on the input from internal experts and stakeholders. Demonstrations C and D that centre around the developed solutions (database and marketplace), will be launched in a later stage and will require the active engagement with external stakeholders. For the demonstration of its solutions, the BIOMATDB consortium will reach out to its vast existing networks. Building on from that, a knowledge compilation exercise was performed to collect further details and information on the contextual and environmental aspects relevant to the biomaterials solutions to be developed, to maximise coverage.

Table 4. Coverage of the BIOMATDB solutions by the identified stakeholders.

Stakeholders	Database	Marketplace
Researchers		
Demanders		
Suppliers		
Enablers		
Investors / policy makers		

2.3 Deployment in a Test Environment

The test environment recapitulates the planned environment as closely as possible, in order to enable testers to assess how the software will look and perform in real-world conditions. Approaching the demonstration phase in this dedicated test environment aims to detect and address problems before the platforms are deployed to the final, real-world accessible to everyone scenario, reducing risk or errors. For both the BIOMATDB database and marketplace, dedicated testbeds are planned on a development server, aiming to replicate the future live solutions to allow the demonstration phase to take place. Access will be user defined and restricted.

3 Testing

3.1 Methods and specifications

By adhering to standardised testing methodologies and documenting the testing process, reliable and meaningful test results can be obtained. As it is deemed critical to have comparable results per method, at least ten participants, with a minimum of two performing the same test, will be employed.

In brief, the testing methodologies are outlined below.

3.1.1 API performance testing (backend system)

The average response time for single to multiple users is assessed through comprehensive testing of all endpoints, employing load simulation. For this, the API is being addressed directly via the respective tool, script, etc. and response times are being recorded and evaluated.

3.1.2 Security (backend & frontend)

On the frontend, aspects such as input validation, authentication mechanisms, and protection against common client-side attacks like Cross-Site Scripting (XSS) and Cross-Site Request Forgery (CSRF) are tested. On the backend, testing involves assessing the robustness of server-side code, databases, and APIs against vulnerabilities like SQL injection, server misconfigurations, and unauthorized access attempts.

3.1.3 Site Performance and loading times (frontend)

The evaluation of loading times is conducted from various regions and different focuses such as images, text, and overall content. Site performance, particularly frontend loading times, is determined by factors such as server response, network latency, and the efficiency of client-side code execution. Testing typically involves measuring metrics like First Contentful Paint (FCP) and Time to Interactive (TTI) using tools like Lighthouse or PageSpeed Insights to assess and optimize the website's loading speed and user experience.

3.1.4 Site design & responsiveness testing (frontend)

Site design and responsiveness testing, encompassing frontend evaluation, web developer involvement, app testing, browser compatibility assessment, and device compatibility analysis (considering display sizes), are being conducted to ensure optimal performance and user experience.

3.1.5 Search engine analysis and optimisation tests

Search engine analysis and optimization tests involve evaluating a website's visibility and ranking on search engine results pages (SERPs). These tests assess factors such as keyword optimization, on-page SEO elements, backlink quality, and content quality to improve a site's search engine performance.

3.1.6 Application query testing (frontend application)

From within the frontend web-app, test for the different requests will be performed by indirectly measuring response time and time-to-paint for different aspects. Measured is the time from the moment a user interaction triggers a request to the server to the moment the requested data is being

sent back from the database via the server to the client. Also, the correctness of the response is being assessed.

3.2 Testing tools and materials

A range of tools and materials will be utilised, and the most prominent ones are outlined below.

3.2.1 Spreadsheets and Docs

These tools are utilised for documentation and tracking purposes. Google Spreadsheets and documents aid in organising and maintaining comprehensive records of testing activities, test cases, and their outcomes.

3.2.2 Postman

Postman is employed for API load and function testing. It enables the evaluation of the web API's performance and functionality by simulating various user scenarios, from single users to multiple concurrent users. Additionally, Postman allows the creation of collection, simulates high load and saves results among other features.

3.2.3 Pingdom

Pingdom is specifically used for assessing the performance of the web application, particularly in terms of site loading times from different geographical locations. This tool helps identify potential latency issues and ensures optimal user experience across various regions.

3.2.4 Eye-tracking software

Eye-tracking software is utilised to evaluate the usability aspects of the web application. By analysing users' eye movements and interactions, this tool provides insights into the visual design, layout, and overall user experience of the application.

3.2.5 Vulnerability scanner

Tools like nmap, apiclarify, or OWASP ZAP are employed to identify potential security problems within the web application. It performs thorough scans and assessments to detect vulnerabilities, weaknesses, and potential entry points that may be exploited by malicious actors.

3.3 Testing guidelines and recommendations

3.3.1 Documentation

Pilot testing and deployment test cases, procedures, and outcomes should be accompanied by written documentation to facilitate clear communication and knowledge sharing among team members. Thus a list of tools will be utilized, as written documents or screen-casts to capture testing activities consistently.

3.3.2 Bug reports

General building blocks of reports

If tests did not meet the specified success criterium or another error has been identified, a bug report has to be filed to aid the developers to quickly and effectively address the issue and implement solutions. Testers should provide step-by-step instructions to reproduce the issue, clearly stating the

expected and actual results, headed by a descriptive title and including relevant screenshots or logs for additional context. Communicating the browser and operating system used, the version of the web-application, and any specific configurations or prerequisites could also provide necessary details for resolving the reported issue.

Trello as a support system

Testers can use pre-defined boards to manage bug reports, where each bug report can be represented as a separate card on the board, as described, with reference to developers. Experts could use labels or tags to categorize and prioritize the severity or priority of the bug. Additionally, due dates can be set to ensure timely bug resolution. Trello's comment feature allows for ongoing discussions and updates on the bug, facilitating effective communication between testers and developers. As the bug progresses through the resolution process, the card can be moved across different stages or columns on the Trello board, such as "To Do," "In Progress," and "Done," providing visibility into the bug's status.

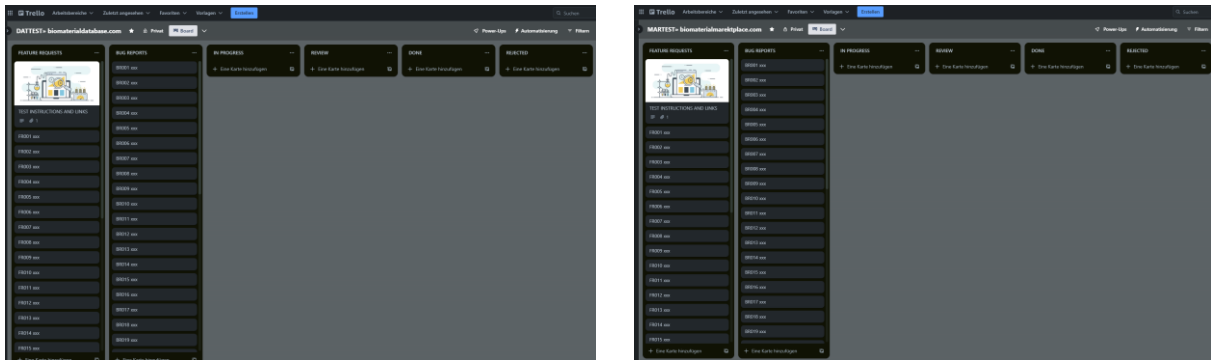


Figure 3. Trello boards for Biomaterial Database and Biomaterial Marketplace

3.3.3 General recommendations

A critical recommendation for testing is to allocate ample time for test planning, ensuring developers have sufficient time to implement necessary changes. Scheduling adequate planning allows testers to define the testing scope, objectives, and requirements thoroughly.

A similar Approach to Testing will be validated and employed for Training.

4 Manual: Training methods, tools, materials and handbooks

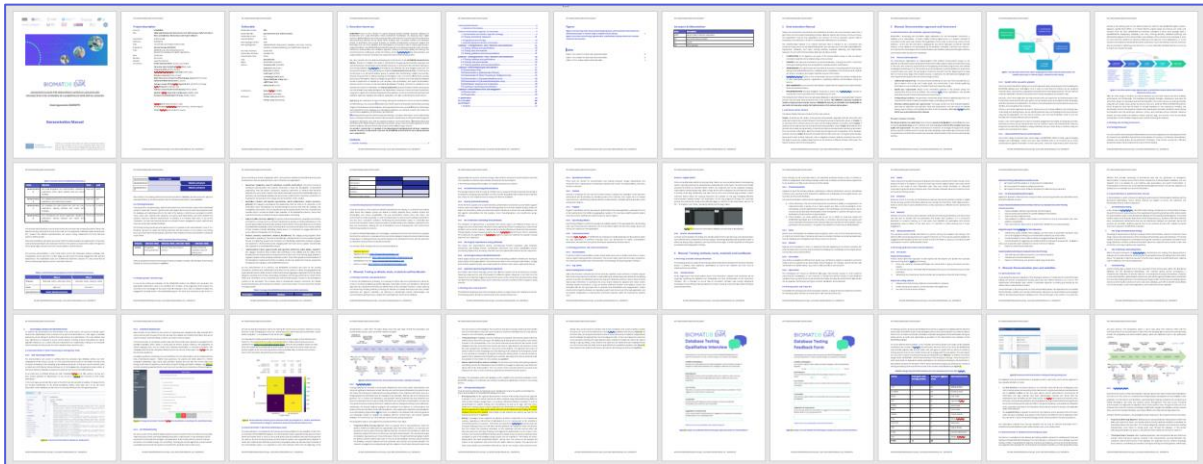


Figure 4. A Demonstration Manual mock-up screenshot

4.1 Training methods and specifications

The following sections describe the training methods that will be employed for the demonstration phases, highlighting their aims and specifications, accompanied by the materials and tools for their implementation.

4.1.1 Train-the-Trainer

The demonstration phase initiates with "train-the-trainer" webinars and workshops, explaining the database and marketplace and their functionalities to the consortium members. This is to ensure that consortium members gain insight and aid setting up training materials and tools, as well as to provide high-quality training to external stakeholders.

These sessions can be conducted either in an interactive workshop format, on-site, or virtually on WebEx or Google Meet. Alternatively, webinars will be held on WebEx, and will provide an opportunity to ask questions in a Q&A session at the end of the webinar.

4.1.2 Train-the-Evaluators

Organise at least five training webinars explaining to external stakeholders how the marketplace should be used, how they should evaluate the database and marketplace and the digital advisor, and how they should provide feedback.

The train-the-evaluators method will be implemented in two different formats.

Online Workshops: The online workshops will be conducted on WebEx, or Google Meet in an interactive format. A group of six or seven people will, after a short presentation of the marketplace, have the opportunity to register in the marketplace, set up their profiles, search for products and test other functionalities of the marketplace in real-time. During the session, participants can ask questions or give feedback.

Online Webinar: An online webinar will be set up on WebEx to show and explain the BIOMATDB marketplace and its functionalities. In contrast to the workshops, the webinar will not be interactive.

Nevertheless, there will be a Q&A session at the end of the webinar, where participants can ask questions. The goal for the webinar is to have around 50 participants.

4.1.3 Demo

Demos of the marketplace and database will be prepared, either in the form of Screencast Tutorials, or in the form of short videos. The demos will show to consortium members and external stakeholders how the database and marketplace looks like and how it can be used.

4.1.4 Manuals

Manuals will be prepared in Word, or PowerPoint formats explaining to consortium members and external stakeholders how they should evaluate the database and marketplace and the digital advisor and how they can provide feedback.

4.1.5 Case studies

Case studies are adapted to different user groups (e.g., demanders, suppliers, researchers, and policy makers) which are guided by an action-based manual. Suppliers, for example, receive manuals with introductions for specific actions, e.g., how to create a profile or add a product.

4.1.6 Q&A Section

The marketplace will include an additional Q&A page, that provides answers on main questions concerning the marketplace, or user scenarios. A request form will be included, in case additional questions come up, which were not yet covered by the Q&A. This way the content of the Q&A section can be expanded continuously, and higher customer satisfaction can be achieved.

4.2 Training guidelines and recommendations

4.2.1 For trainers

Prepare for the audience

Trainers should tailor their approach to both Experts and Non-Experts and provide the necessary resources and guidance. Thus, before training

- Know your Audience: Evaluate participants and divide them in groups of Experts and Non-Experts,
- The more the merrier: remember that Interdisciplinarity is key to unveil both Accuracy and User Experience
- Storytelling: User experience may be collected and presented as stories for future training

Prepare the reading material

1. Prepare (and email) training material or documentation in advance.
2. Outline the purpose, features, and functionality of the digital tools
3. Ask users to think of search scenarios

Maximise training and feedback collection on-site

1. Pair Experts with Non-Experts in small groups for collaboration
2. Pair Non-experts for webtool Usability and Usefulness assessment
3. Pair Experts of same and/or different disciplines for data Accuracy Assessment

4.2.2 For Evaluators/Testers/Participants

Before first approach: Think of various testing scenarios representing plausible real-world data entries for search and data retrieval.

4.2.3 General Recommendations for the Partners that will be involved in the initial Training

Overall Assessment

1. Explore database interface to get familiar with the features
2. Read provided documentation to identify database functionalities.
3. Perform at least 3 different tests
4. Test database on different web browsers and devices to ensure cross-browser and cross-platform compatibility.
5. Take screenshots to report issues or performance bottlenecks and help developers

Weigh the Digital Tools' usability for User Experience

1. Evaluate the overall usability of the database, and take notes on parameters like layout, ease of use and highlight confusing or counterintuitive elements you encountered
2. Evaluate overall usefulness and perform at least 3 different tests for specific biomaterials. These would be expert proposed, and selected for different parameters (such as high impact, commonly used terms, applications with good coverage in database, focusing on terms under BIOMATDB Label Biomaterials Types and Classes
3. Provide feedback on Users' Manual clarity and suggest textual improvements
4. Provide feedback by suggesting any additional features that would showcase the database's value, such as possible search examples to include in the Users' Manual.
5. Report on performance bottlenecks.

Recommendations for Experts involved in the initial Training

1. Test both 3 easy (*simple*) and 3 difficult (*advanced*) scenarios in your field of expertise
2. Evaluate and document Data Accuracy and Advanced Search for Usefulness after filtering for specific BIOMATDB labels
3. Report on Performance, and provide context using screenshots.

5 Manual: Demonstration plan and activities

5.1 Demonstration Plan

To guarantee the seamless integration of the developed solutions, it is imperative to conduct thorough testing and provide comprehensive training across the four distinct streams A, B, C and D. The implemented demonstration plan outlines a systematic approach to testing and training for the defined various demonstration streams.

In demonstration A, the primary focus is on the administration panels. The objective here is to validate the functionality, usability, and security of these panels. Moving on to demonstration B, the spotlight shifts to the data processing and intelligence unit. The primary goal in this stream is to ensure the efficient and accurate processing of biomaterial data and the generation of intelligence. Demonstration C revolves around the frontend components of the Biomaterial Database. The core objective here is to validate the user interface, data presentation, and search functionalities. In demonstration D, the focus lies on the Biomaterial Marketplace frontend. The primary objective is to validate the user interface and search functionalities.

5.1.1 Demonstration A (Administration Panels)

Focusing on testing the admin panels of the Biomaterial Database and the Biomaterial Marketplace, various testing methods are applied to ensure the robustness and functionality of these critical components:

API Performance Testing

In the context of demonstration A, API Performance Testing is employed as a crucial method to assess the performance and responsiveness of the Application Programming Interfaces (APIs) utilised within the administration panels of the Biomaterial Database and the Biomaterial Marketplace. This testing method makes use of powerful state-of-the-art API testing tools (e.g., Postman). With these software tools, comprehensive performance tests can be meticulously designed and executed. Various API requests are simulated, enabling response times to be measured and the APIs' capacity to handle concurrent requests to be effectively evaluated.

Site Design & Responsiveness Testing

Site Design & Responsiveness Testing is employed within demonstration stream A to assess the visual design, layout, and responsiveness of the developed administration panel web interfaces. This testing method involves testing the user interface (UI) design for consistency, accessibility, and adherence to design standards. It further verifies that the admin panels are responsive across various screen sizes and devices, ensuring a seamless user experience.

Site Performance and Loading Times

Within the given framework of demonstration A, Performance and Loading Time Measurement is deployed as a crucial method for evaluating the overall performance and loading times of the admin panels. This approach entails the execution of performance testing to identify bottlenecks, optimise code for efficiency, and reduce loading times.

Security Testing

Security testing plays a pivotal role in the assessment of the admin panels within the Biomaterial Database and the Biomaterial Marketplace. This essential testing process encompasses a comprehensive evaluation of security measures. It encompasses thorough examinations of aspects such as input validation, authentication mechanisms, and defence against prevalent client-side threats like Cross-Site Scripting (XSS) and Cross-Site Request Forgery (CSRF). Furthermore, the testing regimen includes scrutinising the resilience of server-side code, databases, and APIs to identify vulnerabilities such as SQL injection, server misconfigurations, and unauthorized access attempts.

Search Engine Analysis and Optimization Tests

To improve the performance and functionality of the admin panels, the process of Search Engine Analysis and Optimization Tests is carried out as part of demonstration A. In this regard, a valuable testing tool can be utilised to perform thorough analyses and optimisations. The used software tool (e.g., Lighthouse) is employed to assess various aspects, including content accessibility and search algorithm efficiency. As a result, informed refinements are implemented, leading to an enhanced search interface and the provision of more relevant search results to users.

5.1.2 Demonstration B (Data Processing & Intelligence Unit)

Data Harvesting Verification

The demonstration will consist in verifying that the extracted data (PubMed articles and their metadata) from the various sources is in the correct format and that no information has been lost during the harvesting or the uploading to the database processes. To that end, we will manually check a subset and verify that all relevant articles are in the database (by comparing the total number of them) and that the metadata corresponds to what can be found on the official website. As an initial test, all PubMed articles and their metadata (MeSH terms, title, authors, journal, etc.) were already uploaded to Elasticsearch. As can be seen in Figure 5, this amounts to 34.5 million publications.

In the next steps, we will add the results of the NLP tools like semantic annotation of relevant terms and content classification (is the article biomaterial related, study type, etc.). As we add more information to the database, we will ensure it correctly references the corresponding article.

Figure 5. Screenshot of biomaterial database on Elasticsearch

Annotation Quality Check

Data curation can be defined as the process of organising and integrating the data collected from various sources with the goal of turning raw data into valuable and reliable information that can be used for analysis, decision-making, research, and various other purposes.

In the present case, an annotation quality check and data curation were planned to be applied to the available metadata, which implies a crucial step for further analysis related to the application of natural language tools, such as content and metadata classification or semantic annotation. This metadata comes from the extracted PubMed records and consists of two types: the MeSH terms and the chemical substances.

Annotation guidelines containing rules and definitions for this data curation will be created with the help of biomaterial experts. Within these guidelines, the experts will define labels for a further metadata classification step, where each annotator (expert) will only take care of the labels that belong to their field of expertise (not all labels) using the Prodigy annotation software, see Figure 6. An inter-annotator agreement (IAA) is used to ensure consistency and coherence of the annotations.

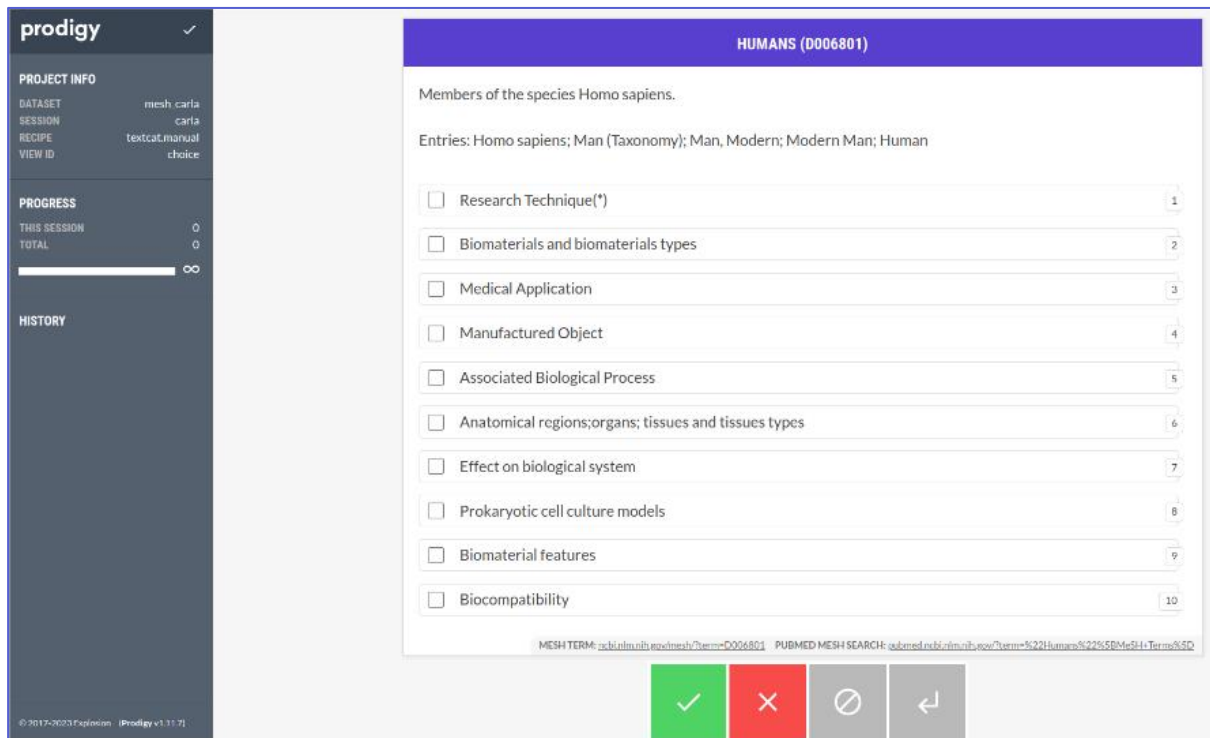


Figure 6. Prodigy screenshot of 'Human' MeSH term classification

NLP Methods Testing

We will use some of the labelled data by experts to assess the performance of machine learning (ML) models by means of the usual train/validation/test splits. A data analysis on the predictions will be conducted to understand the strengths and weaknesses of the models (and thus what to improve and when is not reliable enough). For all methods, including the non-ML algorithms, we will conduct a qualitative analysis with the experts to check that the predicted results make sense.

We will use standard evaluation metrics for training ML models such as confusion matrices, F1-score, precision, recall, overlapping F1-score, etc., depending on the specific task (text classification, named entity recognition, etc). An example of such can be seen in Figure 7.

It is important to emphasise that the ML models will be, at most, as good as the data they were trained on. This means that the quality of annotated data is critical, which will be ensured as specified in the Section 5.3.2 Annotation Quality Check above for the evaluation metrics to make sense and reflect the true performance of the models. At the same time, these models can also provide insights on the errors/incongruencies of the annotated data, so that we can correct or discuss them and refine the guidelines and annotations.

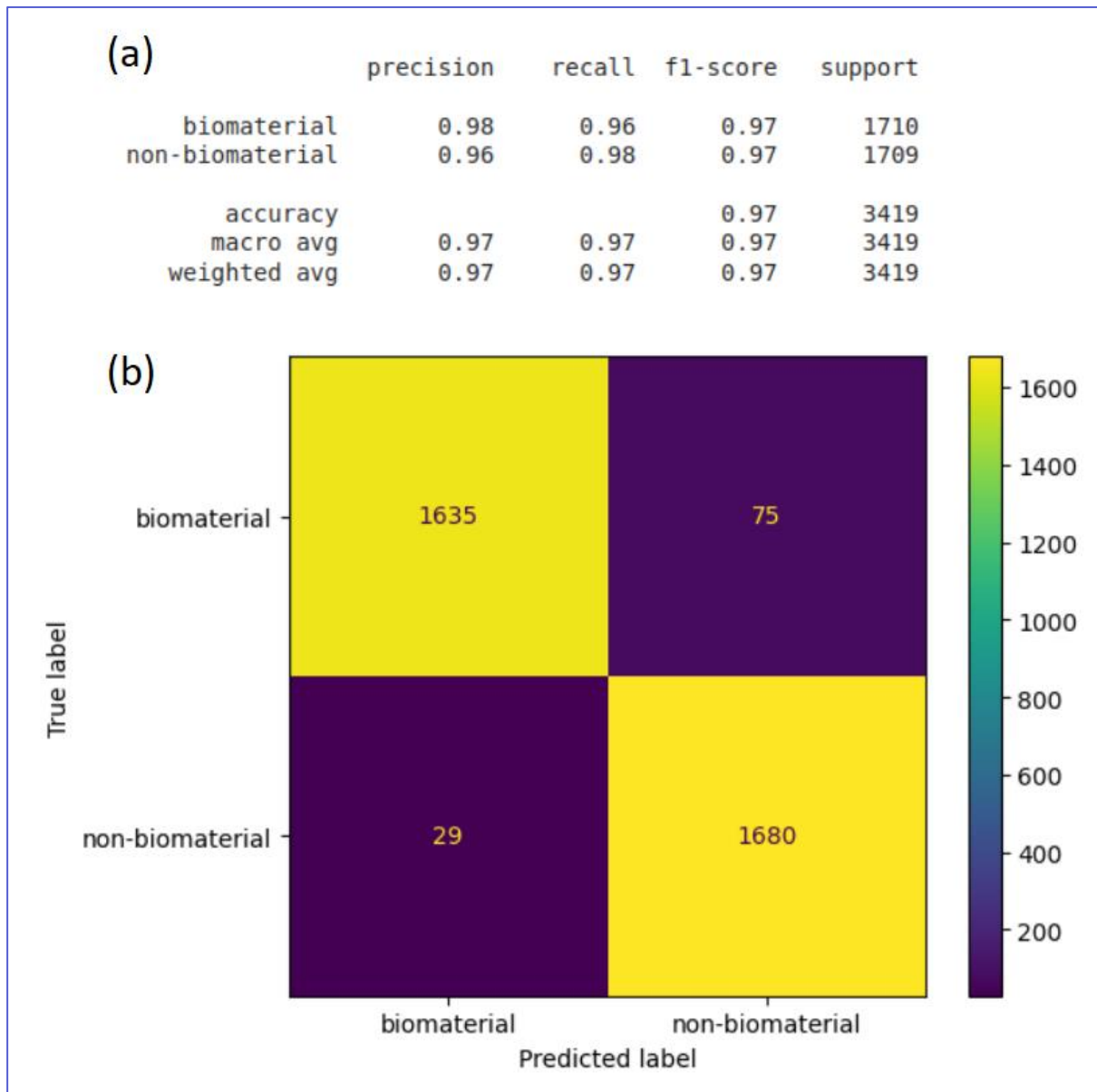


Figure 7. Model evaluation metrics and confusion matrix examples for content classification

5.1.3 Demonstration C (biomaterialdatabase.com)

The demonstration C is dedicated to the training and testing activities for the validation of the front-end interface of the BIOMATDB database. The demonstration itself is expected to take place from April 2024 until October 2024. In order to ensure that all the tools and materials have been developed and are ready to be used during that phase, but also that the partners are organisationally prepared to deliver and implement the activities, a preliminary preparation phase has also been planned ahead of the demonstration phase. It is expected to occur from February 2024 until the beginning of the demonstration, in April 2024. The figure below shows the main steps of both the preparation and demonstration phases, which are further detailed hereafter.

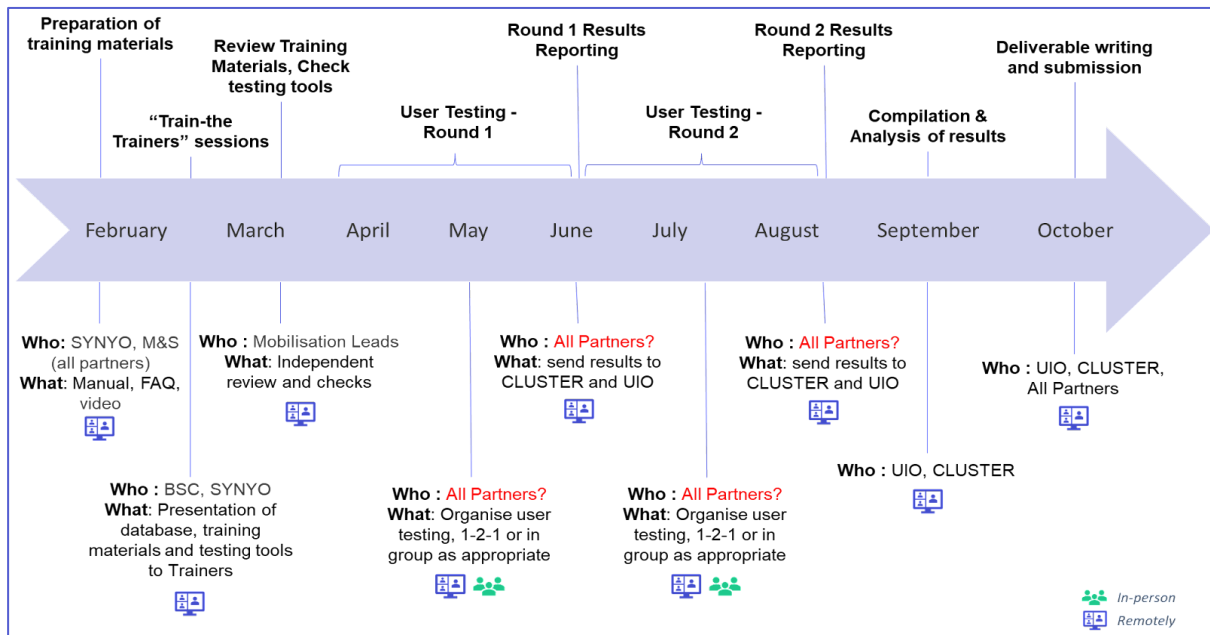


Figure 8. Detailed timeline for the roll-out of the demonstration C (database front-end).

Preparation Phase Overview

Training materials are essential in ensuring the effectiveness and success of this demonstration, and they hold significant importance for both the test users and the trainers/facilitators (the partners who will deliver the training and implement the testing activities). These materials will indeed serve as a bridge between the participants and the database to be evaluated, offering clear and comprehensive guidance. They will enhance the trainers' ability to lead and manage the testing session effectively, contribute to consistency aligning the objectives and expectations across participating organisations. For test users, the objective is to empower them with the guidance and knowledge needed to navigate the database, perform relevant tasks, and provide valuable feedback. This should ensure a more efficient and productive testing experience.

The preparation phase is envisaged to be composed of three main steps:

Preparation of the training materials. With an expected start in January/February 2024, the lead partners will prepare the various types of training materials that the consortium has identified as useful and relevant to support the trainers and test users during the demonstration. This includes the design of a detailed, step-by-step user manual (foreseen in Word or PowerPoint) that will explain to both the partners and the external test users on how to use the database, how they should evaluate the database using the materials and tools provided, and how they can provide feedback. The manual is envisaged to be complemented with the creation of short videos that will visually show the users how to use the database. The consortium also plans to design a FAQ to provide specific and short information on the main queries that the consortium anticipates the user may want an answer to. For more details, see section 4.

"Train-the-Trainers" sessions.

Once the materials are prepared, the technical partners BSC and SYNYO will provide online training on the database and testing tools to the partners who will be involved in the demonstration. This is to ensure that they know what the test version of the database looks like, understand how it works and

have an opportunity to ask questions so they feel well equipped and confident to roll-out the demonstration. This approach will ensure all partners have the same knowledge and understanding of the database and testing tools, which in turn will lead to consistency during the training and testing phases. It will also provide an opportunity to update the training materials in case this step brings to the fore an area that could be explained in more detail.

Review and control of the materials and tools. A final control and review of the training materials and testing tools by the Mobilisation Lead is envisaged to detect any issue before the actual start of the demonstration. This is to ensure all the required elements are ready to be deployed and used, in order to avoid any potential issue further down the process.

Ultimately, the preparation phase will facilitate a more insightful and productive evaluation of the BIOMATDB database's functionality, accuracy, usefulness and usability, benefiting all stakeholders involved in the testing process.

Training and Testing Phase

Once the training materials and testing tools are validated and ready, the partners will initiate the proper demonstration of the BIOMATDB database front-end. Feedback from the deliverable D2.3 will be incorporated in order to prepare relevant testing scenarios and evaluate the right parameters/criteria to assist and guide developers.

- Training sessions will be organised by all partners involved in the testing. They can be organised in groups or 1-2-1 and will be carried out either remotely using videoconferencing platforms (such as Zoom, Webex, Google mee, etc.) or in-person, left at each partner's discretion in order to accommodate for specific settings and circumstances as well as to align with test users' preferences. Training sessions may be organised as an introduction to a testing activity, or it may also be organised as a stand-alone activity that will not be followed by any testing, but where feedback could be still collected. More details on the methods and tools to be used for the training can be found in section 4.
- Testing is envisaged to be organised by partners as either a supervised or an unsupervised exercise, depending on the number of participants (1-2-1 or in group) and on the modality of involvement (online or in-person). The former will require the partner to oversee the test user during the testing process, as it will offer real-time guidance and support to make sure that the test user follows the procedure accurately. As the supervised exercise requires active and focussed supervision, this type of testing is envisaged to be implemented on a 1-2-1 basis. In this instance, it is foreseen that different testing scenarios related to various personas, that have been developed as part of the database design process and are reported in "D2.3 Meta Use Cases, Requirements and Label Specification Report", will be used. The scenario to be followed will depend on the experience level of the test user (either trainee or expert). The supervisor will track a few specific, key information that will be used for the analysis of the outcome of the testing. They could include for example: time to task completion, task success (Yes/No), number of queries, etc. and could be followed by a more in-depth qualitative interview (see [Figure 9; left panel](#)). On the other hand, the unsupervised exercise aims to assess the test user's ability to independently test the database by applying their own knowledge and skills. It does not suppose the supervisor to be constantly checking and supporting the tester, therefore it enables to deliver this type of testing in a group setting. In

this instance, the supervisor will collect test users' feedback thanks to a short survey that will entail succinct quantitative and qualitative questions (see Figure 9; right panel). More details on the methods and tools to be used for the training can be found in section 3.

The figure shows two side-by-side forms for BIOMATDB. The left form is titled 'Database Testing Qualitative Interview' and contains sections for Usability and Navigation, Data Relevance, User Interface, and Functionality, each with a text input field. The right form is titled 'Database Testing Feedback Form' and includes a Likert scale for Usability and Navigation, a Yes/No checkbox for Data Relevance, and text input fields for User Interface, Functionality, and Suggestions for Improvement. Both forms end with a 'Thank you for your participation and continued support!' message.

Figure 9. Examples of a qualitative interview (left), and a short feedback form (right).

The testing scenarios and feedback forms mentioned above will be co-designed and adapted with the technical partners BSC and SYNIO as part of the preparation phase of the Demonstration C (in February-March 2024). This is to make sure that the information requested and gathered from participants during the testing will be as useful and appropriate as possible for the improvement and validation of the BIOMATDB database. The testing will indeed need to cover both usability and usefulness aspects:

- The usability refers to the ease with which users can interact with and navigate the database.

It encompasses factors such as user interface design, accessibility, and overall user experience. A highly usable database ensures that end users can efficiently retrieve information without encountering unnecessary obstacles. While the “technical” usability of the database (e.g. query latency, search and retrieval performance) will be assessed using various tools and techniques mentioned under Demonstration B, the Demonstration C will integrate the evaluation of relevant criteria that were highlighted under the use cases described in “D2.3 Meta Use Cases, Requirements and Label Specification Report”. These include for example the evaluation of the overall user satisfaction in terms of usability and navigation, user interface, and functionality. The consortium envisages to evaluate these aspects using appropriate testing scenarios coupled with qualitative interviews that will include questions as evidenced in Figure 9. A high level of user satisfaction will confirm that the database meets their needs and is simple to use, and free-text fields will enable testers to provide feedback and suggestions for improvement.

- The usefulness pertains to the quality and relevance of the data it contains, indicating the ability of the content of the database to contribute meaningfully to research, development, and decision-making in the field of biomaterials.

A useful database provides accurate, comprehensive, and up-to-date information that meets the needs of its intended users. Here as well, the consortium will use the information from the use cases in “D2.3 Meta Use Cases, Requirements and Label Specification Report” to develop multiple testing scenarios coupled with targeted surveys in order to assess relevant criteria. As exemplified in [Figure 9](#), these include criteria such as the relevance and coverage of the data, the usefulness of the data visualisation, the usefulness of the label of biocompatibility, and others.

A theoretical example of what a testing scenario could be is: ask the tester to perform a search on biomaterial X (selected from a list of pre-selected materials for specific features, as described at [Weigh the Digital Tools’ usability for User Experience](#)) but relevant to their own line of research so they can evaluate the usefulness of the results).

The evaluation of the usability would include criteria such as:

- assessing that the tester is able to perform the search,
- assessing that the tester is retrieving search results,
- assessing that the tester is able to navigate/consult the results without difficulty,
- assessing that the tester is able to visualise results,
- assessing that the tester is able to download results, and others.

The answers to these evaluation criteria will likely be binary (Yes/No) or a specific measure (e.g. time to perform the task).

The evaluation of the usefulness would include criteria such as:

- whether the documents retrieved by the search are highly relevant,
- whether the content matches expectations,
- whether the visualisation tools available (including the label of biocompatibility) are helpful,
- whether there are any unexpected/surprising results that came up and at what percentage, etc.

In this case, the answers to these evaluation criteria will be more in-depth explanations collected via a post-test interview/survey.

The design of the final use cases/scenarios to assess the usability and usefulness of the database will be designed collaboratively between the technical and scientific partners; it will be done during the preparation phase of the testing when the front-end will be ready, and integrate the feedback of the two iterations of external surveys and the internal survey.

Front-End Demonstration Timeline

The database front-end demonstration is expected to start in April 2024, and it will be organised in two separate iterations or cycles:

- The first iteration is currently foreseen to run from April 2024 until the end of May/early June 2024. It will be carried out according to the methods and using the tools that are described above and in sections 3 and 4. At the end, each partner will be responsible for ensuring that

all information and data collected have been appropriately reported and shared with the Mobilisation Lead (CLUSTER) and WP Leader (UIO). The latter will analyse the outcomes of the first cycle, and provide any potential recommendations for improvements that are brought to the fore to the technical partners BSC and SYNYO. The technical partners will evaluate the feasibility of the requested amendments and implement those that are deemed necessary and attainable within the timeframe.

- The second iteration is expected to start from July 2024 and will be executed as the first cycle, with a foreseen compilation and analysis of the results by CLUSTER and UIO in September 2024. Any new trend in terms of requested changes will be communicated to the technical partners.
- The information collected from the two iterations will be used to draft the deliverable D5.2 | Demonstration and validation report (Phase 2) that is due on 31 October 2024.

5.1.4 Demonstration D (biomaterialdatabase.com)

The Demo D is allocated for the training and testing activities required for validating the front-end interface of the BIOMATDB marketplace. This demonstration is scheduled to occur between April and October of 2024. To guarantee the readiness of all tools and materials, and to ensure that the partners are organizationally equipped for conducting and executing the activities, an initial preparation phase has been planned. This preparatory phase is set to take place from February 2024 until the commencement of the demonstration in April 2024. The following figure outlines the principal steps of both the preparation and demonstration phases, which are elaborated upon in the subsequent sections.

Preparation Phase Overview

Essential to the success of the demonstration, training materials are vital for both trainers/facilitators and test users. They serve as a comprehensive bridge between participants and the database under evaluation. For the trainers and facilitators, well-developed materials streamline the conveyance of critical information, save time, and enhance session management. They also ensure consistent communication and alignment of objectives across various partner sites. The goal for test users is to empower them with the necessary knowledge to effectively navigate the database, execute relevant tasks, and provide valuable feedback, ensuring an efficient and productive testing experience.

Similar to the Demonstration C, the preparation phase is planned in 3 main steps:

Preparation of Training Materials:

Starting around January/February 2024, lead partners with input from others, will develop diverse training materials identified as beneficial for supporting trainers and test users. This includes designing a detailed user manual and creating supplementary short videos to visually guide users through the database. A FAQ section addressing anticipated user queries is also planned. More details can be found in section 4.

“Train-the-Trainers” Sessions:

After material preparation, lead technical partners will conduct online training for partners involved in the demonstration, ensuring familiarity and confidence with the test version of the database. This approach aims for uniform knowledge across partners, contributing to consistency during the training

and testing phases. Additionally, this stage may reveal areas in the training materials that require further clarification. Refer to section 4 for more details.

Review and Control of Materials and Tools:

A final review by the Mobilisation Lead is planned to identify any issues before the demonstration commences, ensuring all elements are ready for deployment to prevent potential issues during the process.

Training and Testing Phase (similar timeline to Demonstration C Training and Testing Phase)

In the same context described for Demo C tentative questionnaires will target both the usability and usefulness of the webtools

Usability Evaluation:

Users' experience will be assessed using comprehensive questionnaires, similar to the one below

- Is the navigation within the webtool intuitive and easy to understand? (Yes/No)
- Are you able to locate the desired features or functionalities quickly? (Yes/No)
- Do you find the overall layout and design of the webtool visually appealing? (Yes/No)
- Are you experiencing any difficulties or confusion while using the webtool? (Yes/No)
- Does the marketplace webtool provide clear instructions or guidance on how to use its features? (Yes/No)
- How would you rate the responsiveness and speed of the webtool? (Open-ended)
- Any additional feedback or suggestions for improving the usability of the webtool or the manual? (Open-ended)

Usefulness Evaluation will be similarly approached

- Does the regulatory content provided in the webtool meet your expectations and needs? (Yes/No)
- Were you able to find relevant and comprehensive information related to biomaterials available for purchase? (Yes/No)
- Do you find the data presented in the webtool accurate and reliable? (Yes/No)
- Is the label of biocompatibility useful while browsing among comparable materials? (Yes/No)
- Are there any specific features or functionalities that you find particularly useful or redundant? (Open-ended)
- How would you rate the overall usefulness of the webtool in your biomaterial research or analysis? (Open-ended)
- Any suggestions for enhancing the content or information provided in the webtool to better meet your needs? (Open-ended)

5.1.5 Mobilisation measures and involvement

Mobilisation measures and strategies for involving test users in the demonstrations of the BIOMATDB solutions are pivotal for ensuring the success and relevance of the testing process. The recruitment strategy and engagement channels for testing the biomaterials database and marketplace should be diverse, including partnerships with academic and professional organisations, online community engagement, and personalised outreach. This multifaceted approach will help ensure that the

recruited test users represent a wide range of perspectives and requirements, thereby enhancing the testing's validity and effectiveness.

Recruitment strategy (PIN)

The consortium has already identified the key stakeholders (see section 2.3) in the biomaterials-related field. To effectively reach potential test users within these target groups, BIOMATDB will count on several elements at its disposal.

Pool

Leveraging the professional networks and associations already in place thanks to the diverse composition of the consortium itself. This includes capitalising on access to a pool of experts and therefore potential participants from the academic institutions, research organisations and industry associations that are part of the project.

Interact

The demonstration cycles will be facilitated in cooperation with other projects, including relevant ongoing EU-funded projects as well as relevant DT-NMBP-02-2018 Open Innovation Test Beds (e.g. MDOT, SAFE-N-MEDTECH, TBMED), on top of further networks and practitioner groups being committed to support the project that have provided a letter of support for the submission of the BIOMATDB proposal.

Nominate

The stakeholder identification work performed at the beginning of the BIOMATDB project as part of “Task 2.1 | Collect stakeholder and testbed contacts and run quantitative surveys and qualitative interviews with practitioners on experiences and expectations”, led to the compilation of spreadsheets with the name and contact details of organisations and individuals that would also constitute potential test users. These lists of putative participants can be supplemented with all those followers who actively showed a direct interest in the BIOMATDB project by subscribing to the newsletter or by following the BIOMATDB social media channels.

Engagement channels (REACH)

BIOMATDB partners will reach out to potential test users through various channels that include:

Reach-out

to invitations to colleagues, collaborators and key stakeholders in the biomaterials field using personalised emails or (identified in Task 2.2) can yield enthusiastic participants

Enlist

users using broader, more general outreach thanks to the use of partners' mailing lists that allows for wider engagement of individuals with a keen interest in biomaterials

Advertise

BIOMATDB using social media campaigns and other online channels, such as the BIOMATDB channels, amplified by using and re-posting via partners' online channels

Community

dissemination regarding the BIOMATDB project website by use of an enticing banner on the landing page, or calls to participate sent as part of the BIOMATDB newsletter

High-five

BIOMATDB engaging in one-on-one conversations and presentation at events could constitute other opportunities to introduce the project and its importance and could further pique interest and encourage participation in the testing activities.

It is envisaged that email templates and social media infographics and banners will be created to facilitate the recruitment of participants by the partners and ensure the message is consistent across countries involved.

5.1.6 Continuous monitoring and calibration

Continuous monitoring and calibration are essential during the demonstrations of the BIOMATDB database and marketplace to guarantee the overall success of the training and testing processes as well as the validity of the analysis of the feedback outcomes. Indeed, they will ensure consistency throughout the implementation of the demonstrations and across the different partners' organisations, thereby enabling reliable and comparable results between different sessions and partners' sites. It will help detect any potential issue as early as possible so that corrective actions can be applied in a timely manner. Minimising and addressing potential problems promptly will also help prevent wasting partners' resources. The following measures are envisaged in order to continuously monitor the good progress of the demonstrations and to provide adequate calibration when required:

1 Team-up

Communication between partners is key to warrant smooth delivery of the demonstrations and to enable the identification of any potential issue early on. It is foreseen that WP5 meetings will be held on a regular basis (at least bi-weekly) to provide a platform to share progress, concerns and discuss possible corrective actions.

2 Repeat

The demonstrations for the database front-end (demonstration C) and for the marketplace front-end (demonstration D) are planned to be delivered in two cycles. A first iteration will be followed by the analysis of the results from the first set of tests. This will translate the feedback received from participants into actionable insights in the form of recommendations to the technical teams for refinement and improvement of the two digital solutions. These recommendations will incorporate the main requests on aspects such as usability, functionality and data relevance, and address any identified issues. The technical teams will prioritise them according to impact and feasibility of implementation.

3 Yield

The continuous monitoring and the analysis of results from the first iteration will also likely lead to lessons-learnt in terms of the methods and tools used for training and testing. It is envisaged that for

the second iteration, these may be updated as required to make sure the results of the demonstrations are as comprehensive and useful as possible for the technical partners.

To support the continuous monitoring and calibration approach, the consortium has gone through an exercise of risks identification and mitigations planning, which will provide useful information in the case that issues or problems should arise during the demonstration phase.

6 Risk Assessment and Mitigation Plans

6.1 Process risks

Process risks are potential risks related to the procedures, methods, and technical aspects involved in the testing and training for the BIOMATDB database and marketplace. They can include challenges in the workflow, technology, or systems that may impact the successful execution of tasks, achievement of objectives, or the quality of outcomes.

Table 5. Potential process risks identified and proposed mitigation measures

Risk type	Risk definition	Mitigation measures
Data Privacy concerns	User testing may involve the collection of confidential data from participants	Ensure compliance with data protection regulations (e.g., GDPR)
		Use an Informed Consent form for each participant
Limited testing capability at partners	Partners may lack facility and/or equipment resources to perform and moderate the testing	Be flexible with scheduling to accommodate users' availability and partner conditions
		Define and adapt user questionnaire together with developers
		Use clear communication channels between partners to report any issue
		Discuss and agree KPIs adapted to different partners' capacities
Onerous users' requests	Users may request additional features or complicated changes during testing, which may impact the planned timeline	Document and prioritise user requests for future development
		Plan 2 testing phases to enable feedback incorporation and improvement
Technical Issues	Participants may encounter technical issues (e.g., browser compatibility) that affect their ability to test effectively	Specify recommended browsers, devices and system requirements for testing
		Provide technical support to participants during the testing session
		Have a backup plan in case of widespread technical issues

6.2 People risks

People risks are putative risks associated with the human elements involved in the testing and training for the BIOMATDB database and marketplace. They can encompass issues related to individuals' knowledge, skills, behaviour, communication, and collaboration. They can affect the project's progress,

efficiency, and the overall success of the endeavour due to human error, lack of expertise, miscommunication, or other human-related factors.

Table 6. Potential people risks identified and proposed mitigation measures.

Risk type	Risk definition	Mitigation measures
Low User Engagement	Users may not be motivated to participate actively in the testing process, resulting in limited feedback	Recruit users who represent the target audience with genuine interest in the database
		Clearly communicate purpose and benefits of the testing to participants
		Design relevant tasks for users to perform during testing
		Be flexible with scheduling to accommodate users' availability
		Use user-friendly protocols that make it easy for participants to provide feedback
Communication problems	Poor communication with participants, stakeholders, or the testing team may lead to misunderstandings and delays	Establish clear communication channels and identify contact points
		Provide detailed instructions and expectations to participants
		Schedule regular check-ins with the team of developers
		Use multiple communication channels to reach out to potential participants, such as email, social media, or user communities
Misinterpretation of features	Users might misinterpret certain features, leading to incorrect feedback	Provide clear instructions and guidelines to users
		Conduct training sessions before the testing
		Monitor user actions and intervene if questions or issues occurs
Incomplete Feedback	Users may not provide comprehensive feedback or might overlook certain issues	Prepare a structured questionnaire or set of tasks for users to complete
		Use a well-defined testing plan with specific tasks for participants to complete
		Follow up with users for clarification if needed

Data analysis issues	Misinterpreting user feedback or observations may lead to incorrect design changes	Document feedback and observations clearly and comprehensively
		Follow up with users for clarification if needed
		Combine different testing methods, such as tasks and surveys, to obtain a comprehensive view

7 Conclusions

The path to creating the BIOMATDB Demonstration Manual is well-structured, with five chapters outlining a comprehensive demonstration and validation approach for innovative technical systems and data processing methods.

The document details crucial aspects of the digital solutions, such as:

- **Framework and Architecture:** Outlines elements, design, and architecture, highlighting future capability sourcing.
- **Demonstration Plan:** Four phases (A to D) ensure systematic webtool evaluation and promote data accuracy, usefulness and usability and enhance user experience.

In addition, it provides insight into

- **Testing and Training:** Covers initial testing and training to familiarize users with webtool features.
- **Envisioned Activities:** Insights into activities supporting successful webtool deployment, including roles like the Data Processing & Intelligence Unit, along with the involvement of Trainers and Users.
- **User-Centred and User-Centric Approach:** as it emphasises testing, training, and validation for webtool capabilities and performance and can be tailored to address diverse user needs, respectively.

In conclusion, this document is not just an essential resource for the development and deployment of the webtools. It also reflects BIOMATDB's commitment to exceed user expectations and ensure broad and effective utilisation of the digital solutions under development.

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