Chapter 9

Digital Presentation of and Interaction with Cultural Heritage

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Abstract: In this chapter, the digital representation of tangible and intangible dimensions of Cultural Heritage is presented based on state-of-the-art digital documentation, knowledge representation and authoring of semantic narratives. Such a representation is the result of a systematic process for understanding, recording and representing cultural heritage assets to support preservation and valorisation. In this systematic process we bind the digital representation of the tangible Cultural Heritage remains with their social and historic context and the linked intangible heritage elements propagated between generations. This rich digital and semantic representation provides us with the possibility of creating structured representations of history having as a basis a collection of historic events and encoding the individual interpretations of history in the form of semantic narratives. At the same time, the representation of human activities empowers the creation of representations of processes as carriers of both tangible and intangible heritage. The proposed methodology is the outcome of the research activities under the Horizon 2020 Mingei project with the objective to enhance our understanding on the representation and presentation of Cultural Heritage and entails the latest development of the research field of traditional crafts representation and presentation. In this chapter, the methodology is demonstrated through the representation of the creation of a historic artefact and three alternative interactive presentations on the web, through a Mixed Reality Installation and in the form of a multimodal narrative.

9.1 Introduction

Cultural Heritage (CH) can be conceived as the legacy of physical artifacts and intangible attributes of a social group that are inherited between generations, and preserved in the present for the benefit of future generations. Such physical artifacts are items of Tangible CH (TCH) and include buildings, historic places, monuments, and artifacts, as well as objects significant to the archaeology, architecture, science, or technology of a specific culture (Kalay et. Al. 2007).

Intangible CH (ICH) regards the practices, representations, expressions, knowledge, and skills – as well as the instruments, objects, artifacts, and cultural spaces – that communities, groups, and individuals recognize as part of their CH. ICH is transmitted from generation to generation and is constantly recreated by communities and groups in response to their environment and their interaction with nature and history. ICH provides a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity (Deacon, 2003). Thus, in contrast to TCH, ICH requires its practice by human participants, to exist, or otherwise, be preserved.

ICH includes oral traditions, performing arts, social practices, knowledge and practices concerning nature and the universe, as well as the knowledge and skills to produce traditional crafts (Deacon, 2003). Crafts are defined as "an occupation or trade requiring manual dexterity or artistic skill"[1].

In this chapter, we aim to describe a systematic approach for the Digital representation and presentation of CH capable of revealing both tangible and intangible dimensions. We approach this subject systematically by introducing relevant past research works and establishing our proposed methodology for the representation and presentation of CH. Then, we demonstrate our methodology through four use cases all revolving around the story of a glass artifact. The first use case regards the process of preserving the artifact-making process as a form of interaction of the maker with the material. The second use case regards, the presentation of this process for education and training purposes. The third use case regards, the reenaction of the craft in a Mixed-Reality installation. Finally, the final use case is on storytelling technologies and regards Narrating stories about the creator of the glass artifact.

9.2 Technologies for representing, presenting, and interacting with Cultural Heritage

9.2.1 Tangible and Intangible dimensions

In the literature, CH is often distinguished between tangible and intangible. In this chapter, we will use the example of traditional crafts to understand the space and time where these two meet. We thus propose the following refinement. Artifacts, tools, and sites belong traditionally to the **tangible** domain. As such they are physically transmitted in time through preservation, conservation, and

[1] https://www.merriam-webster.com/dictionary/craft

restoration processes. They are digitally documented using words, photographs, and 3D digitization. Typically, digitization of tangible heritage regards artifacts and sites and is of **static** nature.

Intangible heritage is regarded as an intellectual process that is performed by living humans. It is often referred to as "Living Heritage" and is preserved through documentation, safeguarding, transmission, continuation, and development.

We call the area between the tangible and intangible dimensions, the **"Make"** dimension. For example, during the creation of a traditional craft artifact matter is transformed into an artifact. This transformation is achieved by the actions of a person. The way of creating the artifact or the motif of its decoration may refer to an intangible domain, as it may, for example, depict a story of oral tradition or a regional symbol. To implement this transformation the human uses tools and performs actions. These actions are continuously gauged by the senses of the practitioner, who takes decisions during the crafting process. This area include is relevant to **dynamic** scenes and is relevant to dimensions found in the performing arts, such as human motion. We thus approach the creation event as **a performance with a tangible outcome**.

With the above-mentioned definitions under consideration, we move towards analyzing the prerequisites for achieving the representation of the "Make" dimension for CH preservation and presentation.

9.2.2 Knowledge representation

Semantic knowledge

An important challenge in the studied domain is to expand the capacity provided by traditional documentation methods (text, video, illustrations, etc.). To this end, in the past three decades, the contribution of the semantic web and semantic knowledge representation was essential.

In the Digital CH (DCH) domain, Semantic Web technologies are widely used (Vavliakis et al 2012, Mendoza et. al. 2023). As such, there is a history of approaches followed, since the advancements proposed by Europeana, that introduced the modeling of CH with semantic technologies (Doerr et. al. 2010).

Early attempts at semantic knowledge representation, relied on knowledge classification and focused on catalogs, collections, and artifact descriptions, in object-centric or collection-centric approaches (e.g. Zimmer et. al. 2007, Bloomberg et. al. 2009). In this approach, the migration of heterogeneous data was a major challenge and semantic search was the new provided feature.

New dimensions were given later, through the class "Event" which was one of the basic classes to be included in the Europeana Data Model (Bloomberg, 2010) inherited from the CIDOC-CRM (Doerr, 2003). This was innovative due to the option it provided of creating events that are linked with object-centric representations and thus provide the expressive power of modeling the backbone of history representation. The problem, at that time, was, the lack of data preventing the class “Event” from being populated (Bloomberg, 2010). CIDOC-CRM has undergone several extensions to enhance the representation of the multifaced cultural heritage of humanity (Fafalios et. al. 2023, Doerr et. al. 2020, Doerr et. al. 2018).

In the last decade, breakthroughs in knowledge extraction from texts (e.g. Zhang and LeCun, 2015, Bordes et. al. 2011, Al-Moslmi et. al. 2020, Ntafotis et. al. 2022) and scalable semantic systems based on Semantic Web standards (e.g. Bloomberg, 2010, Clough et. al. 2017, Freire et. al. 2019) offered a signification improvement. By consolidating existing ontologies modern systems provide higher expressivity and domain coverage. Knowledge representation was also supported by the development of new representations of CH artifacts, based on new digitization techniques and knowledge annotation techniques, able to exploit the above-mentioned technological advances (D'Andrea et. al. 2012, Zhao et. al. 2023, Yang et. al. 2023).

Digitizing tangible dimensions

Today 3D digitization technologies have been technologically improved to the point that allows them to be merged for different purposes (Antlej et al. 2011, Pervolarakis et. al. 2023, Wang et. al. 2023). Tangible heritage is perhaps the most studied component of CH, in terms of documentation methodology. Besides photographic documentation, the documentation of tangible heritage increasingly adopts 3D scanning and other digitization technologies. Such digital models have a large range of uses, from the conservation and preservation of artifacts to the communication of their cultural value to the public.

Regarding 3D digitization, the appropriate digitization modality is relevant to the purpose of digitization and the physical properties of the asset to be digitized (Acke et. al. 2021). In the last 15 years, the development of surface scanning modalities for the capture of 3D objects, building structures, or rural spaces, has allowed the representation and documentation of geometrical and structural information about these items (e.g. Jo and Hong 2019). Several modalities have been developed that can be utilized for scene scanning and preservation, each of which addresses different circumstances and records different characteristics of the scanned physical object. These modalities can be further classified according to the sensor type, that is, into passive or active illumination systems. Active sensors emit light whose reflection is utilized for surface detection, while passive utilize ambient light for the same purpose (3D-ICONS, 2014). The 3D digitization of objects still has several open problems, relevant to the accuracy of reconstructions and the digitization of transparent objects (i.e. glass artifacts) (e.g. Ihrke et. al., 2010, Li et. al. 2023, Tai et. al. 2023, Karami et. al. 2022). Currently, the most adopted and robust principles by end-user scanning modalities are (a) Time of flight, (b) Structured light vision, and (c) Photogrammetry (or multiple-view stereo). There is a range of products that employs these principles in variations, such as terrestrial and aerial photogrammetry. In addition, combinations of such principles are found in devices, such as the combination of trinocular stereo with structured light (and IMU information) in various types of handheld scanners.

Passive sensors are typically conventional monochromatic, color, or multispectral visual sensors (cameras). The scanning output is the computation result of a reconstruction algorithm, typically based on the correspondence mapping of multiple views. Active sensors include laser or conventional light emitting techniques to measure 3D information, such as distance range. Some modalities integrate assisting information from an IMU or GPS unit that is operated by auxiliary software components. Passive sensors work with less information as they do not have the advantage of inserting reconstruction cues (i.e. structured illumination) into the environment. As such, they are associated with sophisticated algorithmic approaches and are sensitive to illumination artifacts. Active sensors typically include direct distance measurement methods and are often limited by sunlight, as it is more luminous than the active illumination source of the sensor.

There are significant variations between the capabilities of different approaches. Triangulation techniques provide greater accuracy than time-of-flight (Li 2014) but are reliable in short range and difficult to apply in the field, due to the need for controlled illumination (Blais et. al. 2000, Kim et. al. 2012). When accuracy is a requirement, close access to the scanned object is required. If physical access is impractical, direct distance measurement techniques (time-of-flight) provide less accurate results, particularly when the sensor is airborne and not static. Thus, temporal relevance is the sampling rate of the sensor (i.e., a laser scan lasts much longer than the acquisition of a digital photograph). Also, of temporal relevance, is the time duration that is available for the digitization, concerning the overall time required for a scan.

The capabilities of the different end-user technologies vary in terms of several criteria: (a) Resolution, (b) Accuracy, (c) Range, (d) Sampling rate, (e) Cost, (f) Operating conditions, (g) Skill requirements, (h) Purpose of digitization, (i) Material of scanned object and (j) Weight and transport.

These criteria are to be considered in the selection of the appropriate digitization modality, concerning the anticipated conditions of operation, type of environment, as well as time and budget resources. 3D-ICONS (2014) provided a valuable resource in terms of 3D reconstruction guidelines. Moreover, important resources for the 3D digitization of CH are publicly availed by the non-profit organization "Cultural Heritage Imaging"[2], including tools, technology, and training, for several digitization methods used in the conservation and preservation of Tangible CH. Based on the aforementioned analysis, the applicability of digitization modalities is presented in Table 1.

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[2] http://culturalheritageimaging.org/

Table 1. Applicable sensors per type and size of the environment.

Type/Location	Indoors	Outdoors
Building complex	N/A	Drone (e.g. DJI phantom 4[3]), Camera (e.g. GoPro Hero 11[4])
Large building		
Multiple rooms	LIDAR (e.g. FARO Focus[5]), 3Dcam (e.g. Azure Kinect DK[6]), Handheld 3D scanner (e.g. FARO Freestyle 2[7]), Camera (e.g. GoPro Hero 11[4])	N/A
Large room	LIDAR (e.g. FARO Focus [5])	N/A
Room	LIDAR (e.g. FARO Focus [5]), 3Dcam (e.g. Azure Kinect DK[6]), Handheld 3D scanner (e.g. FARO Freestyle 2[7]), Camera (e.g. GoPro Hero 11[4])	N/A
Small room	LIDAR (e.g. FARO Focus laser scanner[5]), 3Dcam (e.g. Azure Kinect DK[6]), Handheld 3D scanner (e.g. FARO Freestyle 2[7]), Camera (e.g. GoPro Hero 11[4])	N/A
Object, scene detail	3Dcam (e.g. Azure Kinect DK[6]), Handheld 3D scanner (e.g. FARO Freestyle 2[7]), Camera (e.g. GoPro Hero 11[4])	Handheld 3D scanner (e.g. FARO Freestyle 2[7]), Camera (e.g. GoPro Hero 11[4])

Digitizing intangible dimensions

The intangible dimension of CH includes several actions and activities, in various contexts including festive events, traditional crafts, traditional dance, etc. These activities can be digitized in terms of human motion and may be laborious or dexterous and include intangible aspects such as skill, knowledge, and design (Reshma et al. 2023, Skublewska-Paszkowska et. al. 2022). For example, in traditional crafts, human motion is the point where the intangible dimensions of skill, design, and knowledge meet with the tangible dimensions of tools, machines, materials, and artifacts. The preservation of this knowledge is essential for craft valorisation and local development (Bellver et. al. 2023).

[3] https://www.dji.com/gr/phantom-4
[4] https://gopro.com/en/us/
[5] https://www.faro.com/en/Products/Hardware/Focus-Laser-Scanners
[6] https://azure.microsoft.com/en-us/products/kinect-dk/
[7] https://www.faro.com/en/Products/Hardware/Freestyle-2-Handheld-Scanner

Human motion digitization and analysis have gained particular interest in the last two decades, due to the wide range of applications relevant to ergonomy, rehabilitation, security, sports, human-computer interaction, medical education, robotics, cognitive research, entertainment, and many others. The goal is to record the motion of subjects in three dimensions.

Motion Capture (or MoCap) technologies directly measure the movement of subjects in three dimensions, based on wearable markers or sensors whose location and orientation are estimated in 3D (Reuter & Schindler 2023). As such, the resulting data are not necessarily intuitive to visualize without processing. Digitization of human motion has been achieved by several methods, which can classify based on whether they require subjects to wear markers or not (Shi and Wang, 2014). Two main technologies are used (Field et. al. 2009).

The first is based on the optical detection and 3D estimation of wearable markers. This approach typically requires a careful setup environment (i.e. a motion digitization studio or theatre) that includes multiple optical sensors that observe the worn markers from multiple views. The operating principle is the multi-view stereo triangulation of these markers. As such, camera calibration and precise illumination are required. Moreover, a complex motion may require a large number of views, to cope with marker occlusions. These occlusions may be self-occlusions, where markers are occluded by the body members of the subjects, or generic occlusions where markers are occluded by other objects such as, in our case, tools, and machines (Ceseracciu et. al. 2014 and Sarafianos et al. 2016).

The second is based on inertial measurement units (IMU) that are worn. Unlike optical MoCap, inertial MoCap computes the location and orientation based on inertial changes due to subject motion. The results encapsulate human motion in 3D with detail and therefore show a complete representation of the recorded motion. Most importantly, they do not require the setup of a studio or sensors. This is important, as the installation of sensors can be difficult or impossible at the location of craft practice, such as in a traditional craft workshop environment or outdoor rural space (Ceseracciu et. al. 2014 and Sarafianos et al. 2016). Current approaches mainly focus on the digitisation of intangible dimension of folk dance as a form of ICH (e.g. Reshma et. al. 2023, Hajdin et. al. 2019).

9.2.3. Storytelling and Narratives

In literary theory, narratology is devoted to studying the structure of a ‘Narrative’ and how it is represented (Meister 2012). Aristotle defines a ‘Narrative’ as the imitation of real actions (praxis) that forms an argument (logos) whose fundamental units, or events, can be arranged in a plot (mythos) (Aristotele. Poetica. Laterza, 1998). For Russian formalism, a ‘Narrative’ can be conveyed in a wide range of media, including speech, writing, gestures, music, etc. Vladimir Propp’s Morphology of the Folktale (Propp, 1928) proposed a model to represent folktales using building blocks, including thirtyone “narrative functions” and seven roles, or “spheres of action”, of the characters. Claude Lévi-Strauss, in Structural Anthropology (Lévi-Strauss, 2008) outlined a proposed grammar of mythology. A.J. Greimas proposed a system of six basic structural elements of ‘Narratives’ called actants (Greimas , 1983); Tzvetan Todorov was the first to coin the term narratology (Todorov , 1969). Later on, Gérard Genette (Genette and Lewin, 1983) codified a system of analysis that studied both the ‘Narration’ and the act of narrating, considering them separately from the story and content of the text.

Since 1980, post-structuralist perspectives of narratology have been developed. In particular, Cognitive Narratology (Herman 200), considers narratology a psychological phenomenon and proposes a study of ‘Narrative’ aspects from a cognitive perspective. Empirical results from cognitive psychology highlight that most common-sense concepts cannot be characterized in terms of necessary/sufficient conditions. Monotonic description logic captures the aspects of compositional conceptual knowledge but is insufficient in representing prototypical knowledge. Russian formalism distinguishes between a Fabula, defined as a series of events taking place at a certain time at a specific location, and a syuzhet, which is the particular way the story is narrated. Contrary to the order of the Fabula, which is strictly chronological, the order of the syuzhet corresponds to the way the events are presented in the ‘Narrative’ by the author (Propp 1973, Shklovsky 1965). A similar distinction is drawn in structuralism by Chatman (Chatman, 1986), who identifies the opposing concepts of story, i.e., the content that is transmitted, and discourse, i.e., the particular organization of that content. Currently, there is no universally accepted definition of the ‘Narrative’ structure. For instance, Crawford (Crawford, 2012) posits that a ‘Narrative’ is a high-level structure based on causality, not on temporal or spatial relations. Genette (1983) identifies five concepts that characterize the syntax of v: order, frequency, duration, voice, and mood. In addition to Fabula and the syuzhet, Bal (1997) defines a third level that constitutes the concrete representation of the content that is conveyed to the audience (e.g. the text in a novel).

Digital Narratives

Computational narratology studies Narratives from a computation perspective (Paul 2012) and thus refers to story generation systems, i.e., computer applications that create a symbolic (written, spoken, or visual) ‘Presentation’ of a story typically based on a story's grammar. Some of the early storytelling systems are TALE-SPIN (Meehan 1977), UNIVERSE (Lebowitz 1985), and JOSEPH (Lang 1999) which changed the story grammar to create new stories. Other storytelling systems are MINSTREL (Turner 2016), MEXICA (Pérez 2001), and BRUTUS (Bringsjord and Ferrucci 1999). These are hybrid systems that implement a computer model of creativity in writing. Recently, ontologies were used to generate ‘Narratives’such as the MAKEBELIEVE (Liu 2004) system that uses common sense knowledge, selected from the ontology of the OPEN MIND COMMONSENSE KNOWLEDGE BASE (Singh 2002), to generate short stories from an initial one given by the user. PROTOPROPP (Gervas 2005) uses an ontology of explicitly relevant knowledge and the Case-Based Reasoning method over a defined set of tales. In FABULIST (Riedl 2010) the user supplies a description of an initial state of the world and a specific goal, and the system identifies the best sequence of actions to reach the goal. The concept of the event is a core element of narratology theory and the 'Narratives'. People conventionally refer to an event as an occurrence taking place at a certain time at a specific location. Various models have been developed for representing events on the Semantic Web, e.g. Event Ontology (Fernie 2012), Linking Open Descriptions of Events (LODE), (Shaw at. al., 2009), and the F-Model (Scherp et. Al., 2009). More general models for semantic data organization are CIDOC-CRM (Doerr, 2003), the ABC Ontology (Lagoze 2001), and the Europeana Data Model (Doerr, 2010).

Regarding the transmission of knowledge through 'Narratives' PATHS (Fernie, 2012) and CULTURA project (Agosti, 2013) created interactive personalized tour guides to present digital library and CH collections respectively. In the same context, the Storyspace system (Wolff 2012) allowed the creation of curatorial 'Narratives' in a museum exhibition through Events. Each digital object has a linked creation event in its associated heritage object story.

Regarding the authoring of stories with new and existing content, the CIPHER project (Kilfeather, 2003) developed a set of tools to facilitate the development of meaningful stories allowing authors to establish semantic relations between different contents.

Narratives visualisation

Regarding the visualization of 'Narratives' the DECHO framework for the acquisition, ontological representation, and visualization of knowledge (Aliaga et. al. 2011) based on CIDOC-CRM (Doerr, 2003) displays "Narratives" by linking together images or 3D representations of archaeological objects via semantic hotspots (Mazzoleni et. al., 2006). Another visualization tool is provided by the CADMOS suite of applications (Lombardo and Pizzo, 2013) that adopts a computer-supported semantic annotation of 'Narrative' media objects (video, text, audio, etc.) and integrates with a large common-sense ontology (YAGOSUMO). Additionally, The Labyrinth project is an ontology-based system for the visualization of 'Narratives' (Damiano et.al., 2014). In 2015, the Labyrinth system has been extended with a three-dimensional interface (Damiano et. al., 2015). A similar project is Invisibilia, which is focused on the domain of contemporary public art (Lombardo et. al., 2013). Invisibilia takes as input an ontological representation, constructed using a CRM-based ontology for intangible art (Lieto et. al., 2014), and outputs a 3D layout featuring the artworks.

Several tools exist that allow the visualization of data on a particular topic contained in existing knowledge bases (e.g. Wikidata, Freebase) in form of 'Narratives'. For example, Thinkbase and Thinkpedia (Hirsch et. al., 2009) are two applications that produce visualizations of the semantic knowledge contained in Freebase and Wikipedia respectively, allowing the user to explore the semantic graphs of the two knowledge bases in an accessible and interactive way. Histropedia (http://histropedia.com/) allows users to create or view timelines on topics of their choice by importing statements from Wikidata. Links to relevant Wikipedia articles and Wikimedia Commons images are automatically added, resulting in rich spatiotemporal visualizations. The scope of the project includes research, education, tourism, and proprietary applications (Mietchen et. al. 2015).

Narrative authoring systems

The systematic study of Digital Narratives made possible the evolution of a new era of computing systems that aim to support the structured authoring of multimodal narratives. Most of these systems build on semantic web technologies and build on a conceptualization of narratives based on existing knowledge models of the CH sector (e.g. Bartalessi et. al. 2016, 2017, 2023). Such conceptualization resulted in the definition of knowledge models for narratives (e.g. Meghini et al 2021, Bartalessi et. al. 2022).

The Mingei Online Platform

In this research work, we employ one of the latest systems for the semantic web-based representation of narratives, the Mingei Online Platform (MOP) (Partarakis et al. 2021). The definition of the fundamental concepts in MOP was an outcome of a systematic study of HCs in the context of the Mingei project to identify the requirements (Zabulis et. al. 2020) and define the technical components needed for craft representation and presentation (Zabulis et. al. 2019). MOP addresses these requirements and implements the technical framework to support the authoring of 'Narrative' centric representations.

In MOP (Partarakis et. al. 2021 and 2022) all knowledge elements were created through simple form-filling operations. Each type of element has a dedicated Web form in MOP where the relevant meta-data are edited. Furthermore, facilities to identify links with other knowledge elements are provided. Links may be provided in the form of a Universal Resource Identifier for external resources or in the form of semantic links for digital items curated in MOP. Such elements could be for example the linked media objects that are relevant to the knowledge element.

The digital assets hosted in the MOP repository are provided online in conventional and open formats. Each asset has a unique IRI to be directly integrated by third parties. Our knowledge is available to the Semantic Web via the MOP and the SPARQL endpoint exposed. Furthermore, to ensure compatibility with online knowledge sources, definitions of terms are imported to MOP by linking to terms from the Getty Arts and Architecture thesaurus[8] and the UNESCO thesaurus[9]. For further exploitation of

[8] https://www.getty.edu/research/tools/vocabularies/aat/

[9] https://vocabularies.unesco.org/browser/thesaurus/en/

semantic knowledge encoded in MOP, an EDM export facility has been also been implemented allowing (a) export of data in semantic compatible to EDM format and (b) formulate SPARQL queries to the MOP SPARQL endpoint to receive EDM formatted results.

9.2.4. New presentation modalities

The evolution of digital presentation technologies has provided the tools to support multimodal interactive cultural experiences in various media including the web, 3D, augmented, virtual, and mixed reality. At the same time, the evolution of 3D digitization technologies and game engines has led to a paradigm shift from the term digital information to the term digital experience. Although several approaches have been followed to date we will emphasize the ones that are based on Digital Humans for storytelling and process presentation, Web-based storytelling technologies, and Mixed Reality Experiences.

The use of digital humans (DHs) for their digital representation and therefore its preservation, allows the reframing of the way to transmit and deal with content that is difficult to visualize. To that end, the digital human becomes an important element in establishing the connection between the action, the objects, the knowledge, and the environment in learning scenarios (Cadi Yazli et al. 2022, Schroeder et. al. 2023). At the same time, realistic DHs have been employed as sign language avatars (Kipp et. al. 20122, Wolfe et. al. 2022, Papastratis et. al. 2021). Applications of these avatars in CH include their usage as museum narrators to support the presentation of cultural subjects for various target audiences including people with hearing disabilities (Partarakis et. al. 2022, Karuzaki et. al. 2021). The aforementioned potentials for using digital humans is growing due to the wide adoption of these technologies by end users (Li et. al. 2023)

The wealth of semantic information that can be collected by exploring the social and historic context and the make dimension of CH subjects have given rise to systems that represent such knowledge in the form of narratives. Examples of such an approach have been provided by recent research works on the correlation of the social and historic context with culinary tradition (Partarakis et al 2021), the representation of the history of the pre-industrial revolution in the domain of textile manufacturing in Europe (Hauser et. al. 2022) and the presentation of the cultivation of mastic as a form of social activity that formulated the identity of an entire island (Ringas et. al. 2022).

Mixed Reality is a relatively new technology that has been less commonly explored in the CH context. Existing approaches combine physical exhibits with digital information or augment physical exhibits through interactive technologies (Partarakis 2017). In the second use case, we attempt revisiting this technology in the museum context by creating a synthetic environment that augments the visitor to the craft of glassblowing while making the visitor part of the making dimension of a rare glass artifact.

9.3. A methodology for the representation and presentation of CH

In this chapter, we propose a methodology for the representation and presentation of CH rooted in the work of the Mingei project for the representation and presentation of Heritage Crafts (Zabulis et. al. 2020, and Zabulis et. al. 2019). The methodology is comprised of a six steps process that initiates with the understanding of the CH element under study and leads to experiential presentations that are impactful for the CH domain (see Figure 1).

Before analyzing each of these steps, we provide the definitions of the key concepts employed in this methodology (a) Socio-historic context, (b) Event, (c) Fabula, (d) Narrative, (e) Narration, (f) Presentation, (g) Presentation Segments, (h) Process schema and (i) Process (Zabulis et. al. 2022).

"Socio-historic context" regards the representation of history based on the cultural and historical events taking place at the time when the source studied (text, archive, artifact, etc.) was created.

An **"Event"** is something that occurs in space and time, including actions by individuals, as well as complex activities, by groups of persons or individuals. More formally, an 'Event' is the changes of state in cultural, social, or physical systems (Doerr, 2003). In MOP, events are considered to occur within a time interval delimited by time instants, and the convention is also made that Events may have zero duration.

A **"Fabula"** is a series of events taking place at a certain time at a specific location connected in chronological order. Sources of interest contain accounts of events that occurred, by whom, where, in which way, etc., and which are relevant to the topic.

A **"Narrative"** is an abstraction that represents the story to be told e.g. "The history of textile weaving at Krefeld".

"Narration" is the way that a story is told. There can be many 'Narrations' of the same story, focusing on different aspects of the Fabula, or presenting events in a different order. The encoding of the event sequence in the 'Narration' is called the plot.

"Presentations" are defined as the alternative ways that a 'Narration' can be presented. A presentation in the context of this work employs some medium e.g. a mobile device, a VR headset, a web browser, etc.

"Presentation Segments" are components that when put together create the "Presentation".

For the formalization of processes, we use the following definitions.

A **"Process schema"**, is a conceptual term that relates to an archetypal plan that can be demonstrated verbally and described, i.e. as instructions. In our case, it is a digital semantic representation of the archetypal plan.

A **“Process”**, is the execution of a “Process schema” digitally and semantically represented as a series of events.

Step 1. Understanding and Recording

During this step, a mapping of the topics and knowledge items to be documented is established. The pursued outcome is an identification of the entities required to comprehend (a) the CH element and (b) the social and historical context of the CH element. Prior knowledge of the topic catalyzes progress in this subject. This preparatory task regards secondary source research. The targeted sources provide an identification of the basic concepts and their appellation. Recordings of objects (endurants) and events (perdurants) may be needed to complement the documentation with visual aids. The result of this step is a collection of CH elements and the information for their representation in multiple forms (texts, scanned documents, photographs, audio-visual archives, 3D reconstructions, etc.). This step often requires new digitizations to complement pre-existing knowledge sources and data.

Step 2. Knowledge Elements

The basic CH elements are instantiated following a semantic model for CH representation. These elements are the conceptual entities identified in Step 1. For example, materials, objects, places, periods, etc. are of interest in terms of representation. The instantiation of knowledge elements refers to the creation of a record for each via the assertion of semantic metadata and relations, as well as the linking of digital assets. Thus, knowledge elements contain curated information encoded as knowledge statements and links and their instantiation is a digital curation task. The user task includes the selection of the entity type, the provision of the semantic metadata for that entity, and the linking of digital assets relevant to the entity. This is done by employing the Mingei Online Platform (MOP) through simple form-filling operations. Examples of this process are presented in section 9.4. - “Step 2. Knowledge Elements”.

Step 3. Representation

Representation, in the proposed methodology, may regard (a) the definition of Narratives that present a story based on the recorded socio-historical content or (b) the definition of processes that encapsulate the modeling of human activities.
In the case of Narratives, the representation starts with their definition in textual form. We call these text-based narratives and combine textual information on the knowledge elements identified during Step 2. These text-based narratives provide the building blocks for the definition of Events which are

a core part of their semantic representation. Thus in this Step, the entities represented in Step 2 are related to the representation of a CH element through the contextualization of Events and the definition of Fabulae. Fabualae is collections of events that are the backbone of a narrative. Events are organized by relations to formulate a time-space continuum.

In the case of processes, we propose activity diagrams that are borrowed from the Unified Modeling Language (UML)(Object Management Group, 2007) and used in the following sense. While UML represents computational actions that transform data, in this work, physical actions are modeled. The transition nodes Transition, Fork, Merge, Join, and Branch are used for the activity diagrams. The transition node is used to model the progression of sequential events in the crafting process, ie. Step 1 leads to step 2 and step 2 leads to step 3. The Fork node is used to represent the initiation of two parallel events, i.e. step 1 occurs in parallel with step 2. The Merge transition is used when two or more control paths unite, while the Join node is used to connect steps that should be completed before the transition to the next step. Merge and Join transitions are structurally similar. However, in a Join transition, there is synchronization across a set of parallel flows, while in a merge only a single flow is active. Finally, Branch transitions connect a step with a decision step that accepts tokens on one incoming edge and selects one outgoing alternative. Branch nodes control the flow of a process by selecting one of several alternatives, based on the outcome of a condition evaluation.

Step 4. Representation of narratives and processes

Text-based narratives are transformed into semantic narratives via authoring in MOP. Narratives implement the ways that fabulae are presented or narrated (Partarakis et. al. 2021). Contextual events are used in narratives and are events that have occurred in the past. Narratives are represented following a formal ontology specification (Bartalesi et. al. 2016, Meghini et. al. 2021). A narrative may have multiple narrations. Each narration contains references to events of the Fabula in some particular order that is not necessarily chronological. Individual narrations may differ because we wish to present them in multiple ways, for various audiences, and through a multitude of presentation modalities. Each narrative contains a reference to a Fabula and a reference function that determines the order by which events in the Fabula are narrated. In this way, knowledge elements and digital assets associated with the event are accessible to the narration. Individual narrations of a narrative may be adapted per language, age, or special needs. Last but not least, narrations may differ due to their adaptation to the format of the presentation medium, whether it is audio, visual, textual, or multimodal.

To represent the orchestration of stimuli presented during a narration on a particular medium, the concept of presentations is used (Meghini et. al. 2021). For each event referenced by the narration, a presentation segment is authored. This segment contains the links to the digital assets to be presented

during the narration, or their spatiotemporal arrangement. Authoring presentation segments is facilitated by the MOP, through the retrieval of knowledge entities and digital assets.
In the case of processes, the activity diagram is transcribed into a transition graph. The MOP UI facilitates the structure and enables the instantiation of process schemas and their steps. Data fields are used to enter appellations, informal descriptions, and step orders. Transitions are instantiated via dynamic UI components that adapt to transition type.

Step 5. Presentation

Presentations are built on top of events and event schemas referenced through the narrative and associated with knowledge elements and digital assets, which can be retrieved to illustrate the narration. Narrations are associated with events and, in turn, with knowledge elements and media objects. Presentations are medium-specific and thus the semantic knowledge for each one can be used for online rendering or exported to support the authoring of alternative forms of presentations powered by presentation modalities. Presentation modalities are considered the alternative technical means of displaying a presentation. For example, an audio-visual book is receiving (through export) the information to be presented in a structured format following the requirement defined by the rendering application. Thus, such a presentation modality is capable of rendering whichever presentation of narration is authored with a specific style.

Step 6. Impact

Supporting multiple presentation modalities for CH knowledge creates a grid of experiential technologies on top of which narratives can be presented. This has the immediate effect that culture accessed in books, archives, museums, archaeological sites, etc. is provided with a brand new set of dissemination possibilities powered by immersive technologies but with the utmost respect to the scientific knowledge of the domain. By having all information scientifically curated and transformed into narratives by the educational departments of each hosting organization we bring the power of knowledge to the hand of CH experts and support the dissemination of knowledge through a vast amount of experiential means thus making culture more appealing to the potential audient. At the same time through a scientific process for the representation, the proposed methodology provided the means for the preservation of the represented knowledge ensuring semantic interoperability.

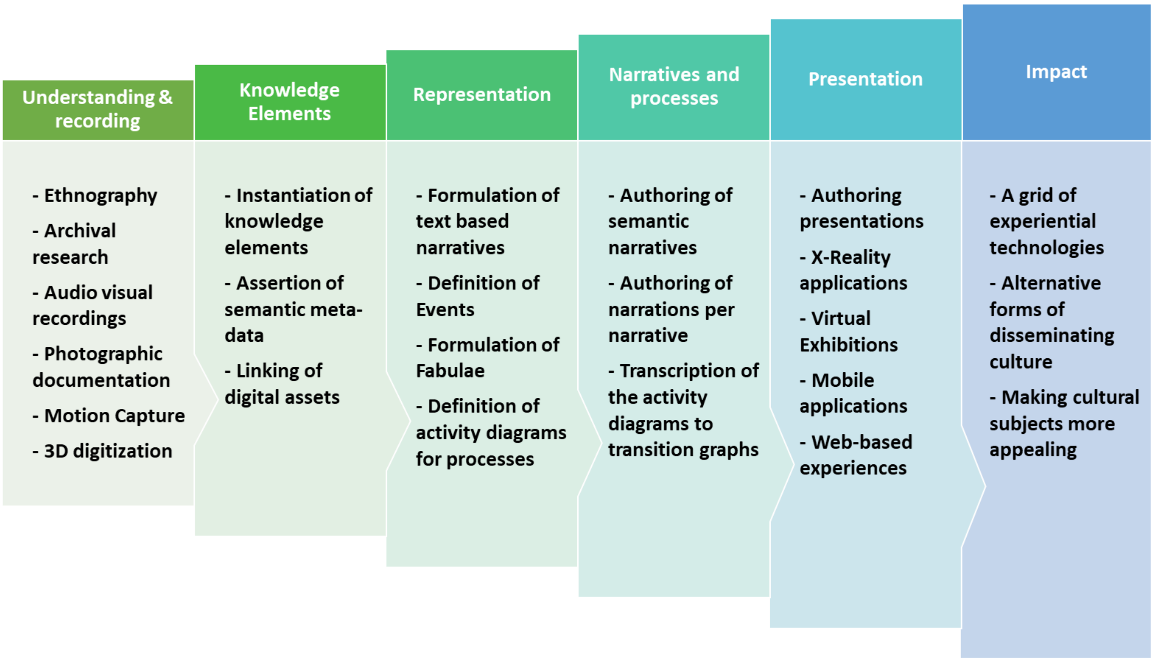

Figure 1. A methodology for the representation and presentation of CH.

9.4. Use Case - Preserving the creation of a historic artifact

As mentioned in the introduction, the use cases selected to demonstrate the application of the methodology for various purposes, revolve around the craft of glassblowing and the making process of a historic artifact a glass carafe. The design of this particular glass carafe was initially created by Georges Bontemps who was a famous French glassmaker of the 19th century. The documented process of the glass carafe took place at the Centre Européen de Recherches et de Formation aux Arts Verriers (CERFAV) in the context of the Mingei project.

In the first use case, the creation of this particular historic artifact and its linked tangible and intangible dimensions is considered. Tangible dimensions regard the artifact itself and the tools, machines, and workshops involved in its creation, while intangible dimensions are connected with the crafting process and the knowledge of the practitioner transferred during the dexterous manipulation of tools and material.

Step1. Understanding & recording

To understand the craft of glassblowing, ethnographic principles that included background research of secondary sources were followed. Initially, a study on literature resources was conducted focusing on the historic artifact (a glass carafe) to be re-created in the workshop. Then, ethnographic work which involved interviews with the practitioners and fieldwork observation was performed to dive deep into the individualities of the crafting process. This understanding was supported by audiovisual recordings and documentation of the interviews and the craft demonstrations. The detailed ethnography enabled our understanding and supported the documentation of gestures, techniques, and steps of a crafting process. The output of this process was a vocabulary of terms on glassblowing with verbal definitions and visual descriptions of the involved objects (nouns) and actions or activities (verbs) and a detailed description that supports the study of the recorded activities beyond the content of the visual demonstrations. For example, for each visual demonstration, the actions performed by the practitioner are defined and described lexically including the preconditions and postconditions of their execution.

Recording: As described earlier pertinent assets regarded conventional audiovisual data acquired from the ethnography such as audio and video interviews and photographic documentation, as well as documentation to be used for craft representation including photographs and video documentation of objects, spaces, and demonstrations. Examples of ethnographic recordings are presented in Table 2. Furthermore, in this step, further digital documentation was acquired from documenting photographically and in 3D materials, tools, products, and workspaces.

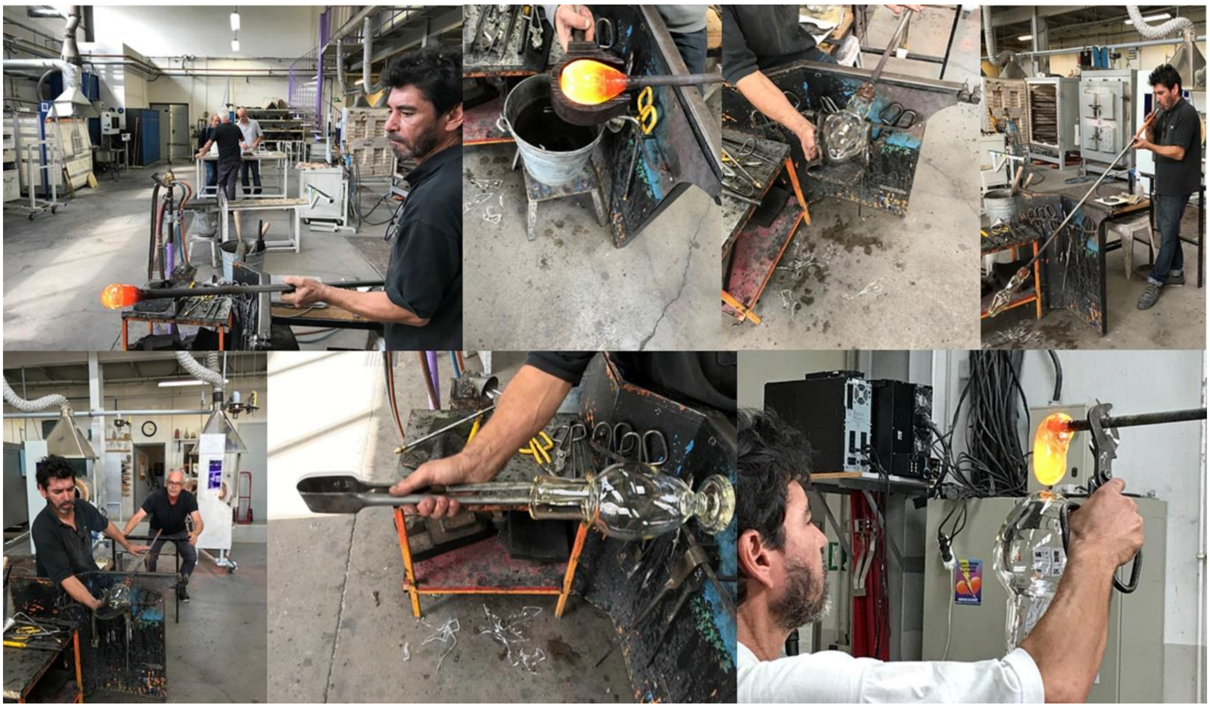

Figure 2. Examples of video documentation at CERFAV.

In this step, we distinguished between the potential historic significance of an object and its utility as a tool. For non-historic objects such as e.g. tools, their geometrical structure can be sufficient. The use of manually created 3D models simplified digitization tasks and significantly reduced scanning costs. The collection of tools for glasswork (Kokolantonakis, 2020) is summarized in Figure 3.

Figure 3. 3D models of glass workshop tools.

Similarly, for the creation of 3D models of machinery, using the acquired audiovisual documentation during ethnography we created the machine using 3D modeling software. The outcomes of the modeling process are presented in Figure 4.

Figure 4. 3D models of glass workshop machines.

Documentation of motion occurred in the context of this research work, through Motion Capture sessions that took place during the ethnographic fieldwork at CERFAV, in September and October 2019. During this, fourteen carafes were produced in the workshop to observe and capture social and body interactions that take place during glasswork. Apart from the audiovisual documentation acquired, the process was recorded using MoCap equipment and, in particular, the Nansense MoCap suit and Gloves.

Step 2. Knowledge Elements

In this step, ethnographic outcomes, vocabularies, and a detailed description of the craft were processed and curated in MOP. These digital assets represented objects and actions involved in the process of glassblowing and contain photographic and 3D documentation of materials, tools, products, and workspaces and additionally recordings of the practitioner crafting actions while practicing the craft. In this context, photographic documentation, video recording of the creation process, 3D objects, and 3D reconstructions were uploaded to the Mingei repository and documented in MOP. Motion recordings were also stored in the repository and documented in MOP to formulate Motion Vocabularies. All digital assets received unique IRIs for semantic interoperability. Photographic, audiovisual, and 3D assets were ingested in MOP and browsed by file properties and by thumbnail preview, as shown in Figure 5.

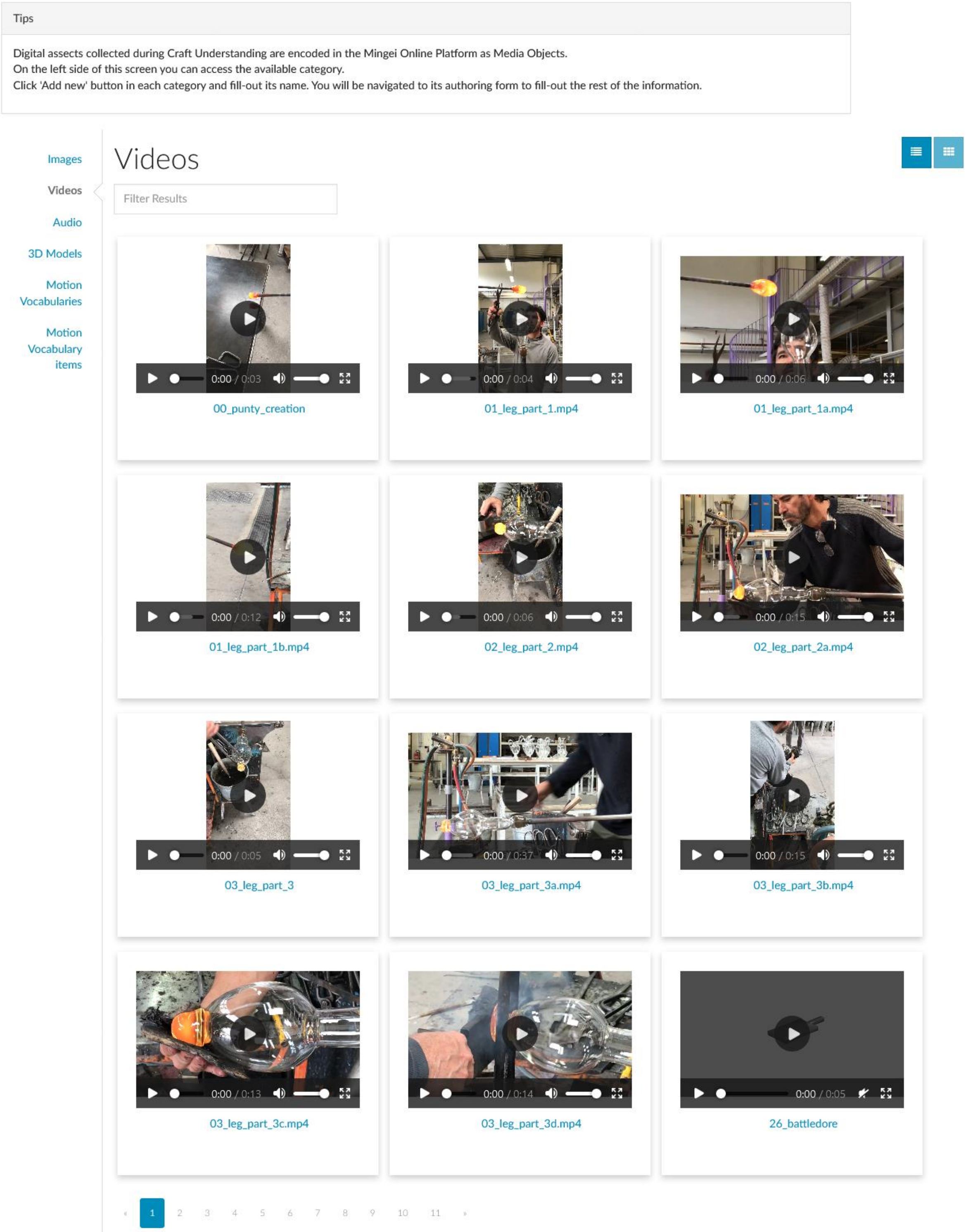

Figure 5. Digital assets

Step 3. Representation

In this step, the objects and actions of the carafe-making process were semantically represented. The representation uses a few classes, called basic knowledge elements, which contain links to semantic metadata provided by the curator and links to the digital assets formed in the previous step. From motion recordings, reference postures and gestures were identified. To associate frames and segments from motion recordings with postures and gestures respectively, the AnimIO annotation editor (Partarakis et. al. 2020) was employed, which facilitates body-member-specific annotation of motion recordings. To represent tool and machine usage, motion recordings and 3D models were combined.

The recordings were combined under the context of the Event knowledge entity, which contains links to the representations of the Location, Participants, Tools, Materials, and (intermediate) Products pertinent to the event. Conceptually, events were aligned with the steps of the process and, both were then hierarchically analyzed in sub-events and sub-steps.

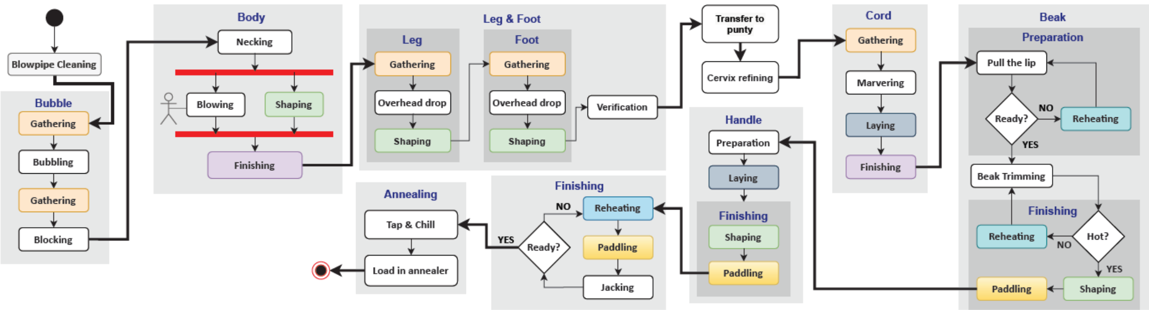

Figure 6. Activity diagram of the carafe creation process

Furthermore, in this step, the activity diagram of the carafe-making process was transcribed into a transition graph. Using the MOP UI we structured and instantiated the process schema, its steps, and the transition nodes that connect the steps. An example of the carafe-making represented process schema is presented in Figure 7.

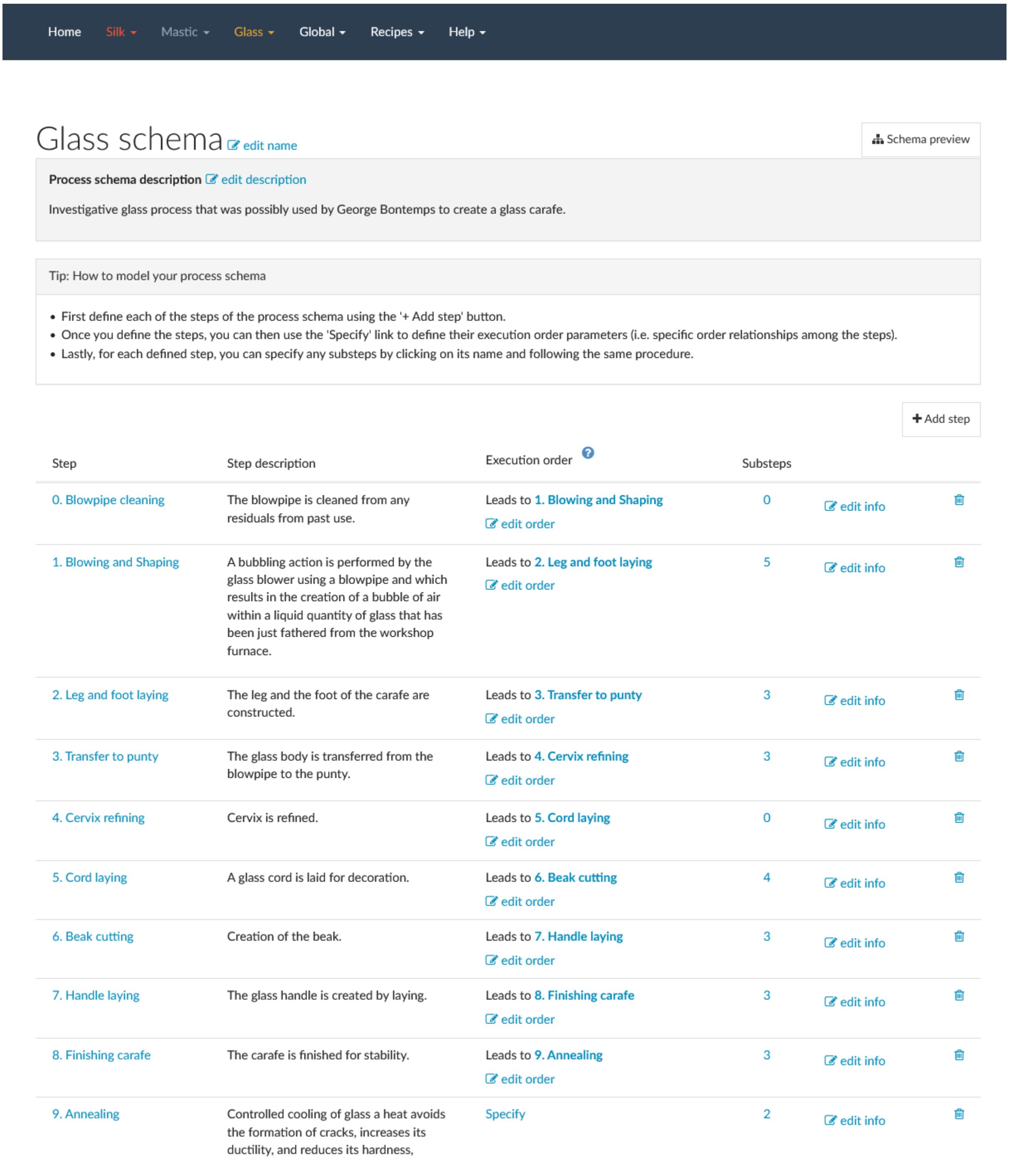

Figure 7. Process schema representation in MOP

Step 4. Processes representation

Process representations account for the events that took place during the execution of a process schema. Intuitively, a process is an individual flow of events, out of those possible in the activity diagram. The MOP UI enables the instantiation of processes representation, via the entry and chronological ordering of events, accompanied by the recordings that document them. In the case of the carafe-making process, the produced process representation in MOP is presented in Figure 8. As shown in this Figure the process is decomposed hierarchically into steps and sub-steps, adheres to the Glass schema, and is linked to materials, and tools utilized in the process. At the same time, the process is associated with other relevant basic knowledge elements documented in MOP, such as the persons (participants) that performed the process, i.e. the glassblowers, as well as the location where it took place and other media objects, i.e. images, videos, etc., relevant to the process.

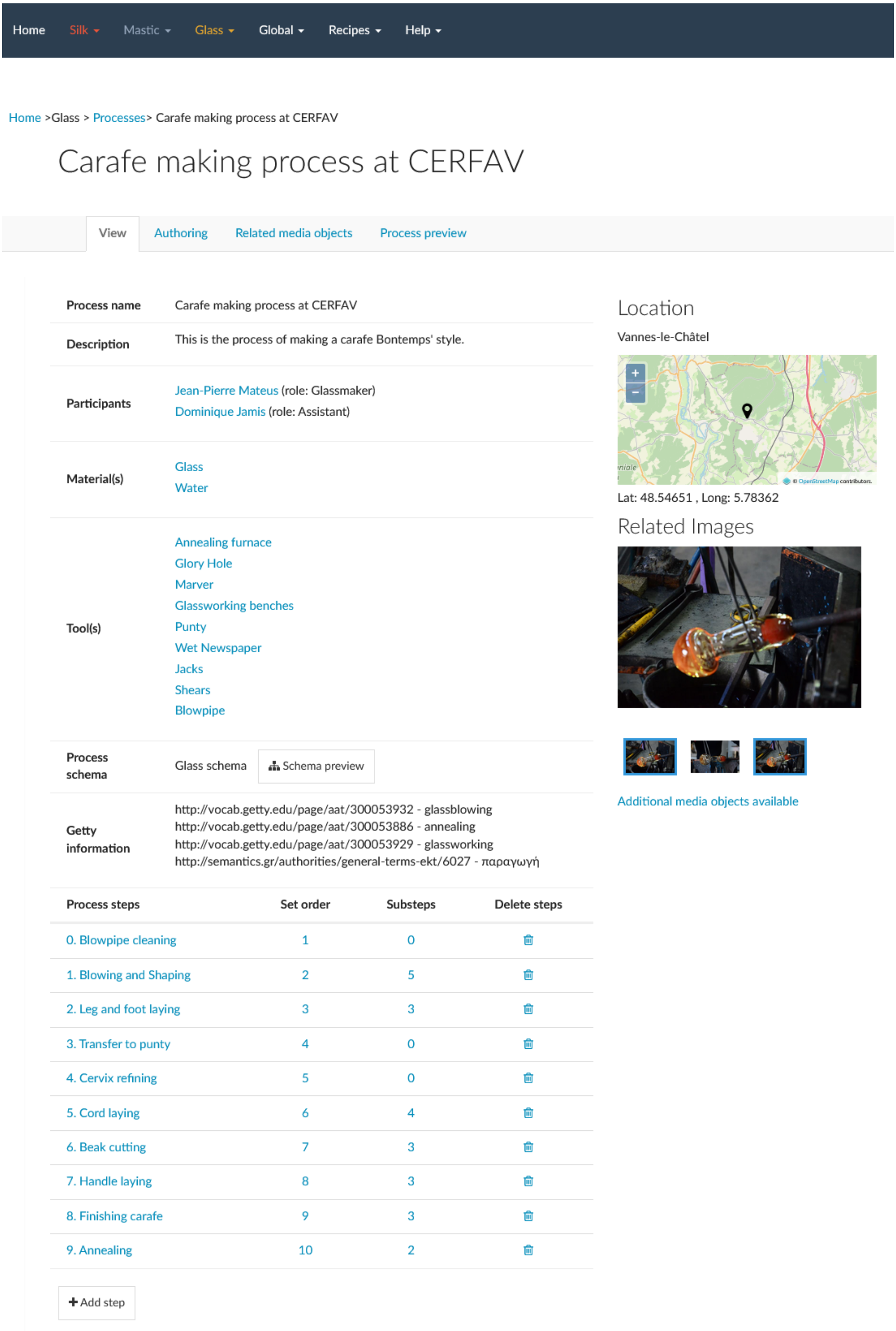

Figure 8. Process representation in MOP

For web-based demonstration purposes in MOP, each process is presented in a user-friendly manner as a series of activatable steps each one correlated to it-substeps and bearing information on the usage of tools and segments of the audio-visual recordings of the process execution. In Figure 9, the web-based presentation of the carafe-making process at CERFAV is shown, its links to relevant basic knowledge elements are shown on the left, and the process steps with respective media representation are shown on the right of the figure.

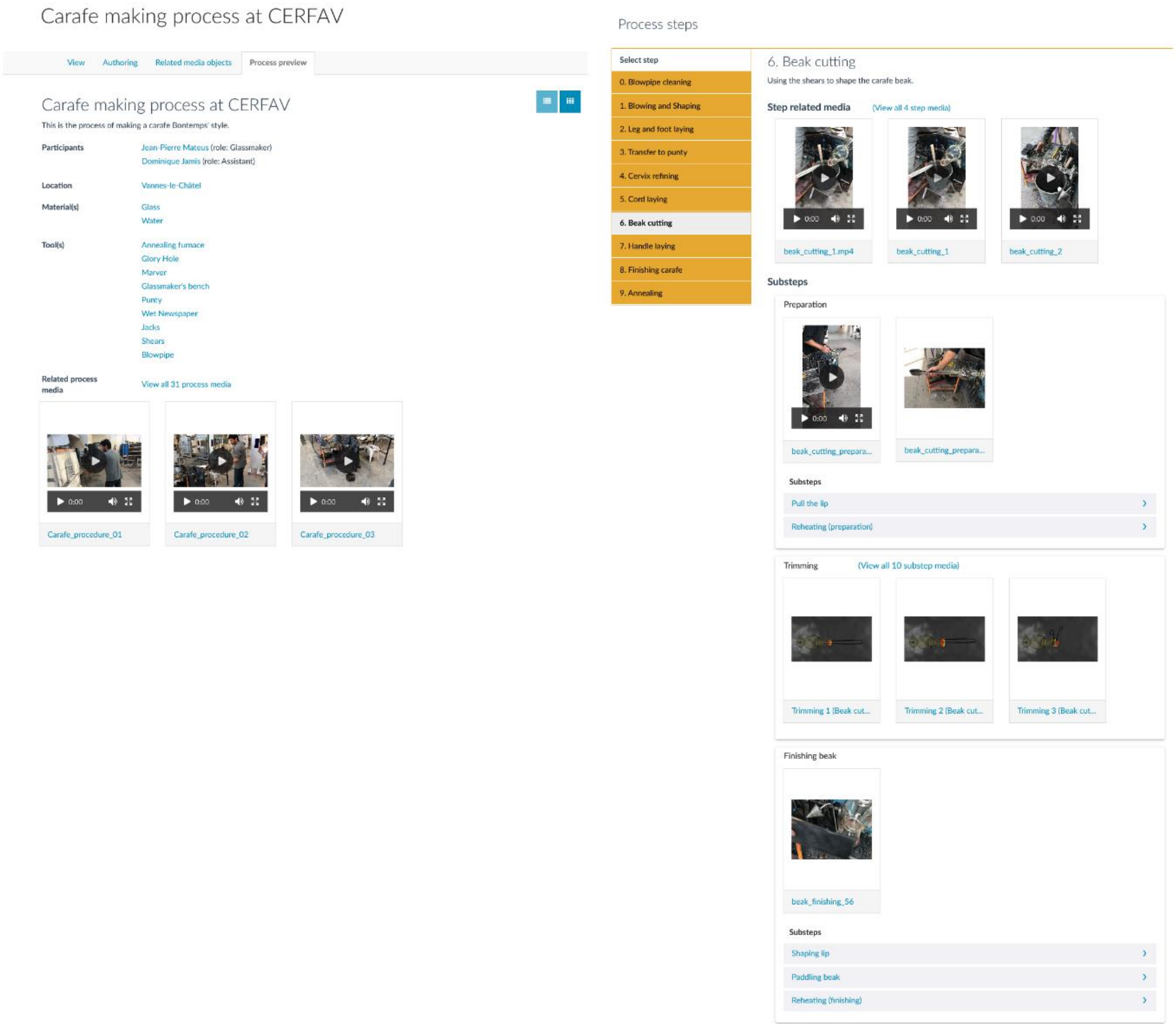

Figure 9. Process preview in MOP

Step 5 Presentation

The represented knowledge network on the carafe-making process is available through the WWW and the MOP in hypertext format. Based on this network several presentations can be built as illustrated in the used cases of the following chapters.

Semantic links are implemented as hyperlinks that lead to the pages of cited entities. Contents are also organized and presented thematically, per class type. A keyword-based search is also provided. Documentation pages contain links to digital assets, textual presentation of metadata, and previews of the associated digital assets. For locations and events, specific UI modules are provided. For locations, embedded, dynamic maps are provided through OpenStreetMap[10]. Timeline and calendar views are available for events.

The vocabularies formulated in the first step of the craft representation are provided as illustrated vocabularies of tools, which bring together verbal descriptions and visual recordings. In the same way, the steps where a specific tool is used can be retrieved, along with video recordings of such actions; and similarly, for the tools and materials required for a certain process.

Processes are presented containing links to the recordings of the knowledge elements for the tools and materials involving the participating practitioners, the date, the tools employed, and the location of the recording. If the process follows a process schema, a link to that schema and its preview are also provided. The hierarchy of process steps is presented using insets, each one presenting textual information and previews of the available digital assets. To present step organization, insets are dynamically unfolded to any depth of the process hierarchy, associated with image previews and embedded videos. Variations include images and textural descriptions.

9.5. Use Case – Presenting the creation of a historic artifact

Based on the representation of the glassblowing process presented in the previous case we can provide several experiential interpretations for craft demonstrations.

Through the post-processing of the original digital assets, we can provide simplified visualizations for illustrative purposes. Such visualizations reduce the information provided for example by a video recording of the essential parts of the craft to be presented. A collection of enhanced iconic abstractions of tool usage gestures is presented in Figure 10. For example, in the first row of Figure 10, the picking up of hot glass material is presented in the first two figures while the other two present the creation of form using a hand-held tool. Using the same rationale several steps are also visualized in this figure in a form of abstraction that presents only the tools and their interaction with matter.

[10] https://www.openstreetmap.org

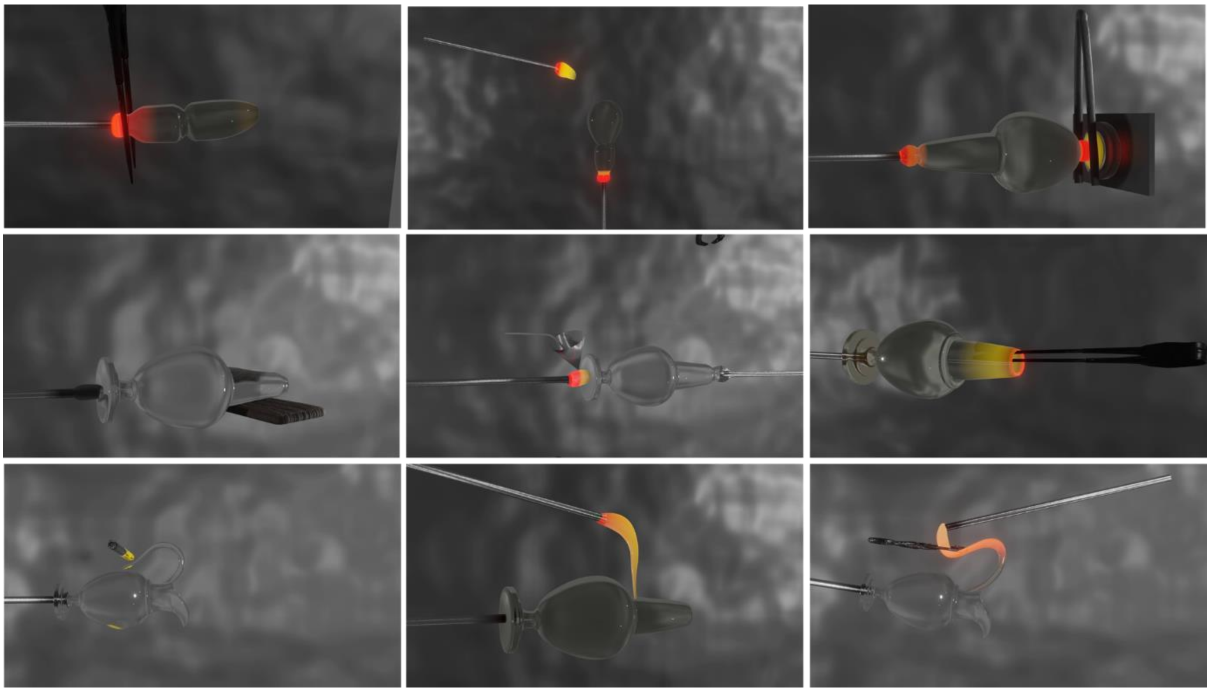

Figure 10. Computer-aided, VR presentation of glassblowing processes.

A more intriguing presentation is the re-enactment of the carafe creation process in a virtual environment. For the implementation of the workshop in 3D, the High Definition Rendering Pipeline (HDPR) offered by the Unity3D[11] game engine was used. The virtual human bodies and clothes were created to obtain one unified and optimized model, enhancing the visual impact of the characters with texture mapping and material editing. The 3D generation of the virtual bodies has also to take into consideration the total number of polygons used to create the meshes to keep a balance between the 3D real-time simulation restrictions and the skin deformation accuracy of the models. For Virtual Human motion MotionBuilder was used to create an actor with a skeleton definition corresponding to the Biovision Hierarchy (BVH). Then the transposition of the recorded animations (.bvh files) to the VH was performed followed by a synchronization of the VH with the actor by adjusting the 2 models so that the measurements match and the animations are correctly reproduced (retargeting).

Tool Handling during animations was implemented using animation rigging, which enables users to animate a mesh with the use of a skeleton, as well as other use cases like runtime rigging. Runtime rigging is when a skeletal animation is modified during gameplay using constraints as a post-process. Useful scenarios include attaching hands to props or aiming the head in reaction to a gameplay event like a character passing by. Rig Constraints are also used to affect objects in reaction to the

[11] https://unity.com/

skeleton's motion.

9.6. Use Case - Interacting in a Mixed Reality Exhibition

The results of this research work were deployed in the context of a periodic exhibition at the premises of the museum of Conservatoire national des arts et métiers (CNAM) in Paris, which is where the worlds of academics and professional activity come together. It is the only higher education establishment dedicated to life-long professional training. In this context, a dedicated space at the cathedral which is part of the museum was dedicated to the exhibition.

For binding, all the above-described components with the MOP and the ethnographic fieldwork three synchronized content view spaces were implemented. The main view space is a simulation of the crafting process for creating a glass carafe and combines the modeled workshop and tools VHs and animations of VHs together with the dexterous manipulation of tools. The second view space presents close-up views of the gestures of the glassblowing VH to enhance the understanding of the audience regarding specific crafting gestures used in the making process. This is a compilation of the first view space with a specific arrangement of virtual close-up cameras. The third application presents the tools used in each step of the process to enhance the understanding between craftsmanship, gestures, and tools.

The installation was comprised of a special construction capable of hosting three large displays created through back projection in thin synthetic fabric. Furthermore, for craft training, a bench was installed in front of the main display together with a glassblowing pipe to be used by visitors. The installation integrated hosting spots for the glass carafes and pieces of the carafe created during the ethnographic fieldwork. Special lighting was integrated to present the interaction of glass with light and to create an atmosphere. After the completion of the physical part of the installation, the software was installed in the computers hosting each projection and their intercommunication was set up. Figure 11 presents the craft presentation applications installed and running within the installation space.

In the computer hosting the glassblowing presentation, a second application was installed which is dedicated to crafting training. This application allows users to mimic craft gestures using the tools and the bench. The scenario that was set up was that the presentation application sequence is executed first and then the main projection switches to the craft training applications so that users test what they learned from the craft presentations. To do so, an application was used to control the order of execution of the craft presentation and craft training applications.

Figure 11. Craft presentation applications installed at CNAM

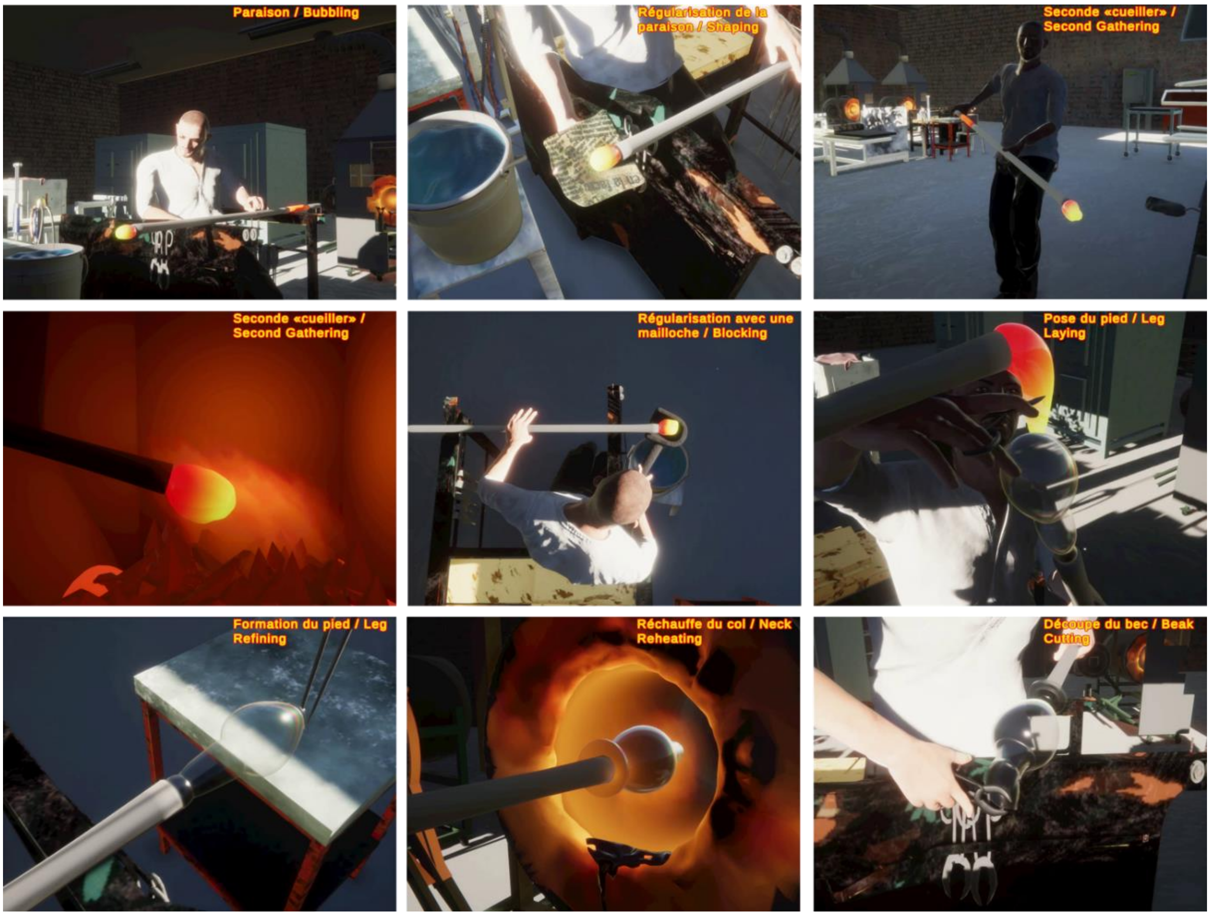

Figure 12. Craft training screen

9.7. Use Case – Narrating the life story of the original creator of the historic artefact

In this use case, a narrative is created to accompany the rich knowledge of the creation of the Georges Bontemps-designed Glass Carafe. For this purpose, in step 2 we created knowledge elements relevant to the social and historic context of industrial glass blowing in France complemented with a unique historical document in the possession of the CNAM. These included Persons, Places, and Events. Through 2D scanning, we digitized the manuscript of Georges Bontemps and Péligot concerning glass manufacturing and we represented it in the MOP. Then, in step 3 the main life events of Georges Bontemps were semantically represented and linked with the social and historic context. Then, we grouped these events in chronological order to create a Fabula representation. The resulting Fabula representation in MOP can be seen in Figure 13.

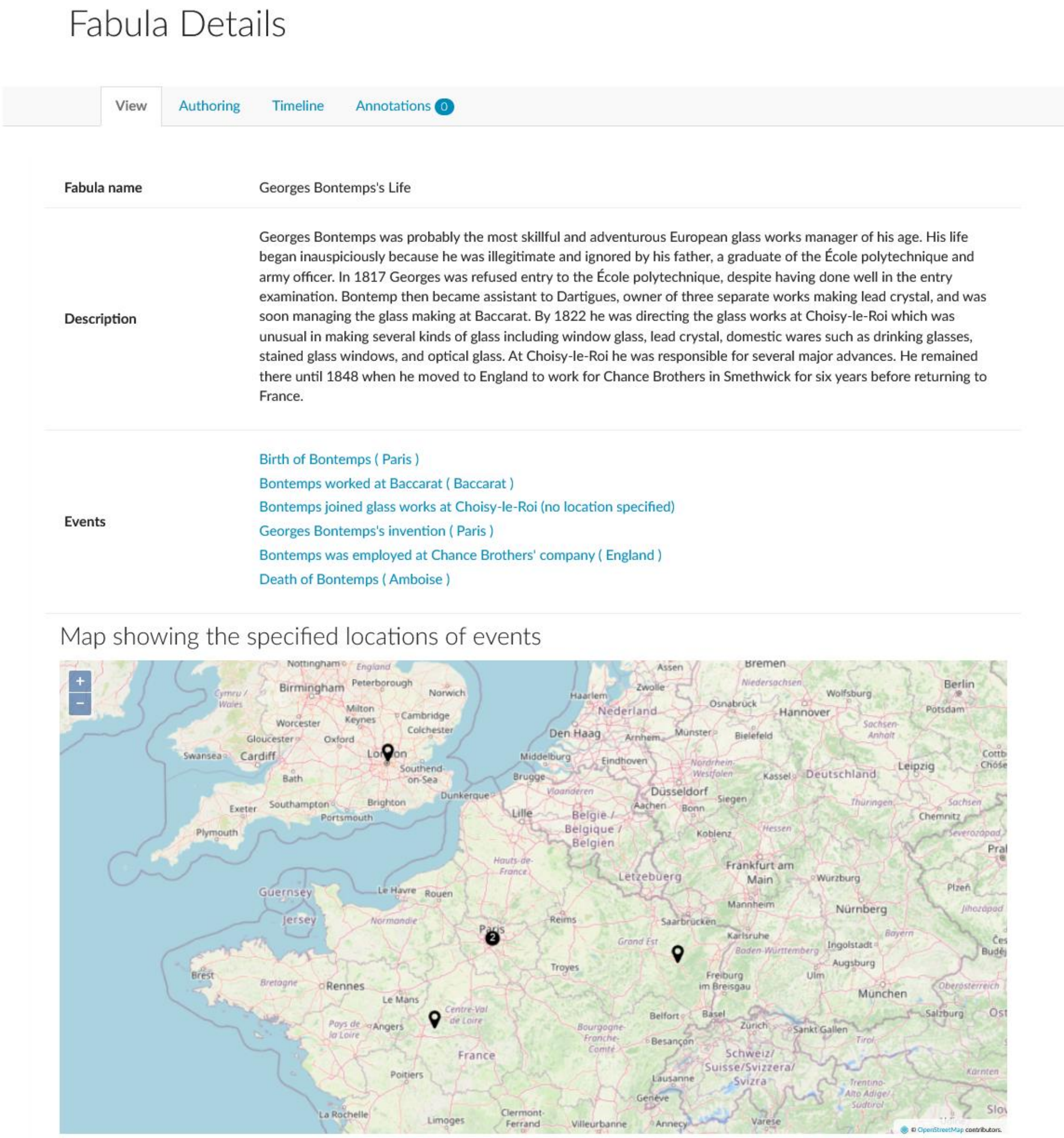

Figure 13. Representation of the Fabula in MOP

In step 4 the main Narrative was created which represents the life of George Bontemps. The Narrative is titled “Bontemps' life” and adheres to the events presented by the Fabula. A Narrative is a container of multiple Narrations each one representing an alternative way of narrating the story. Each Narration may have one or more presentations which are the ways of presenting the story for different audiences and/or presentation mediums. This can be seen in Figure 14 where a Narration titled “George Bontemp’s Life” has been associated with the Narratives and the presentation titled “Bontemp’s life presentation” has been associated with the Narration.

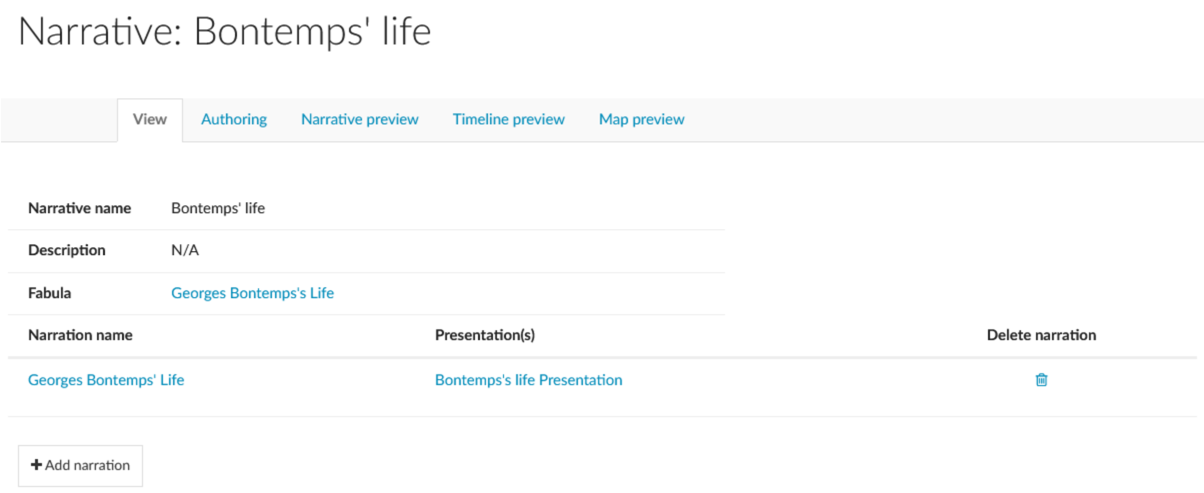

Figure 14. Details and content of a Narrative

By selecting the Narration more information can be accessed regarding the list of available presentations (see Figure 15). Each presentation is associated with several segments which are used for its presentation. Alternative options are supported for making presentations interoperable with multiple presentation modalities through exporting. There is an option to export all the information in CSV or JSON format. The export creates a dump of the entire presentation while also integrating all media assets through their public IRIs.

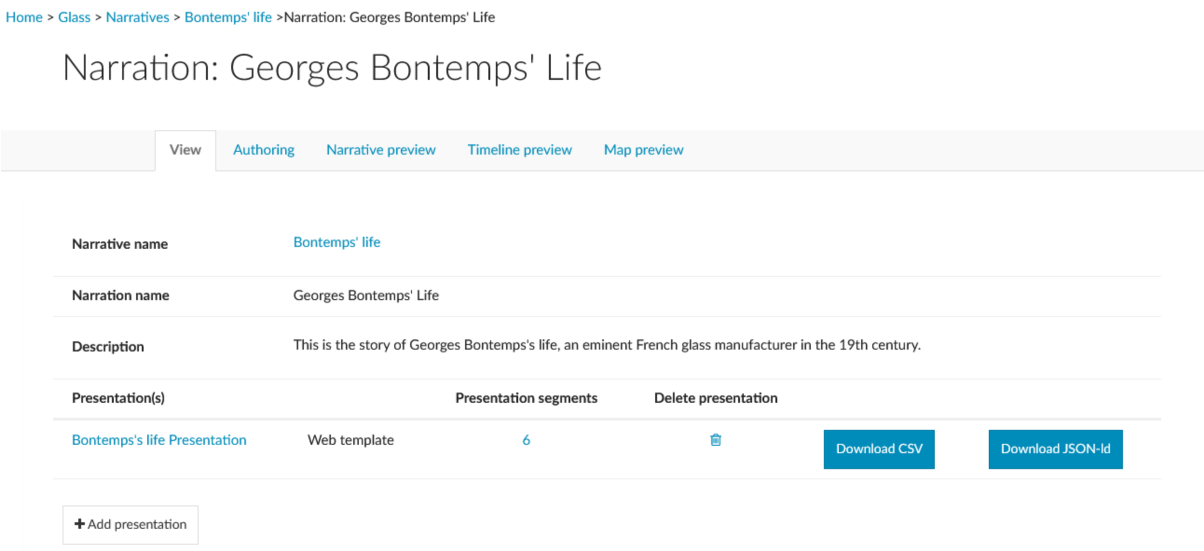

Figure 15. Details of a Narration

The details of the presentation contain all the presentation segments and their viewing order (see Figure 16). Viewing order differentiates based on the type of presentation. For example, in the case of a web page, we assume a linear viewing order with placeholder widgets for additional details linked to the presentation. Thus in the preview of such a presentation, the viewing order is just an integer number. In an audiovisual presentation, the order is depicted by the time span and the channel in which each presentation segment will appear.

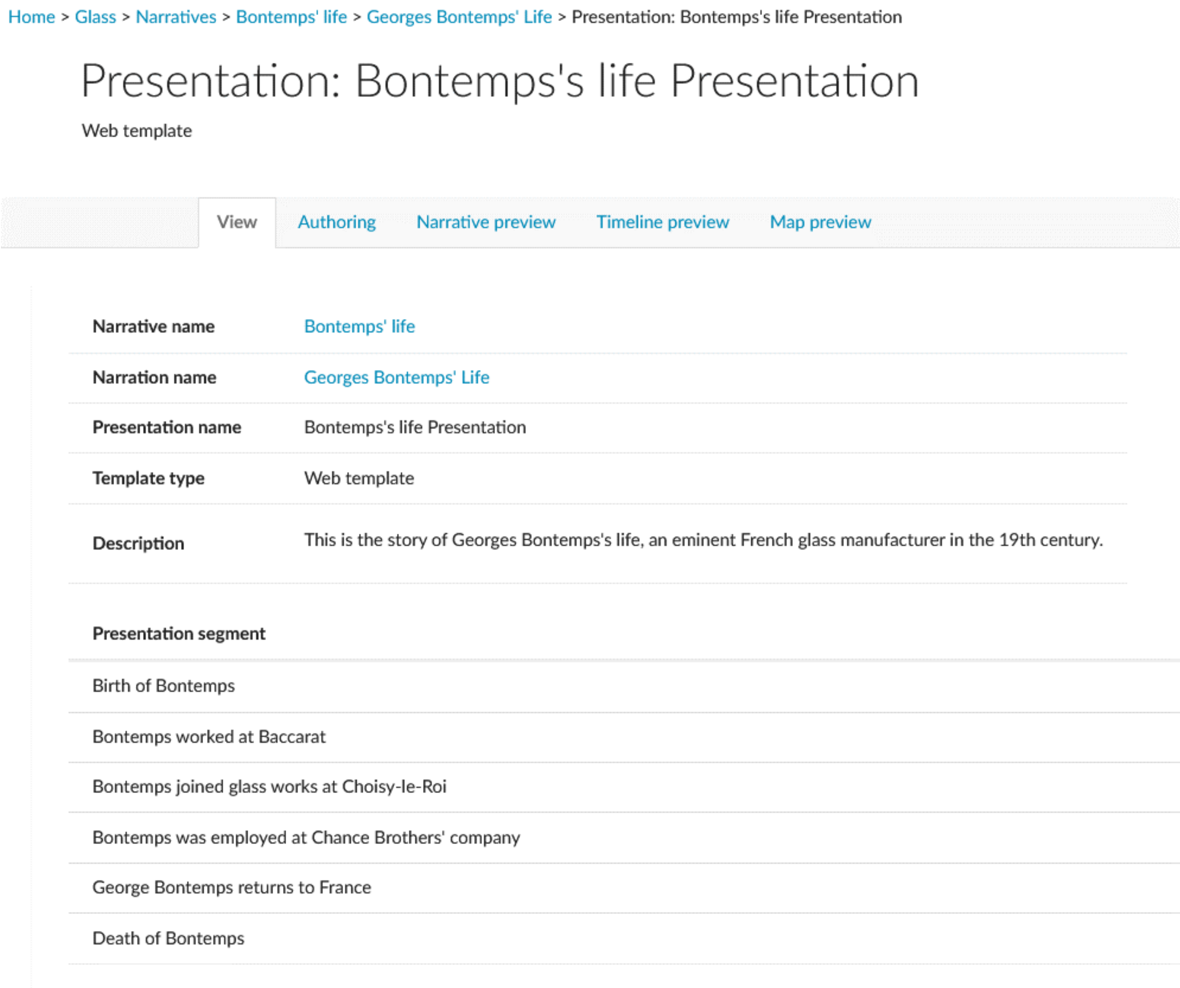

Figure 16. Presentation details and viewing order

In Figure 17 an example of rendering a web-based presentation is displayed. The main body of the page regards the rendering of the presentation segments while at the end of the presentation, two supported views are integrated. The first regards the chronographic display of the associated events using a timeline metaphor while the second regards the map-based representation of the places and locations that are relevant to the presentation. Key persons and events are displayed on the right-hand side of the presentation page.

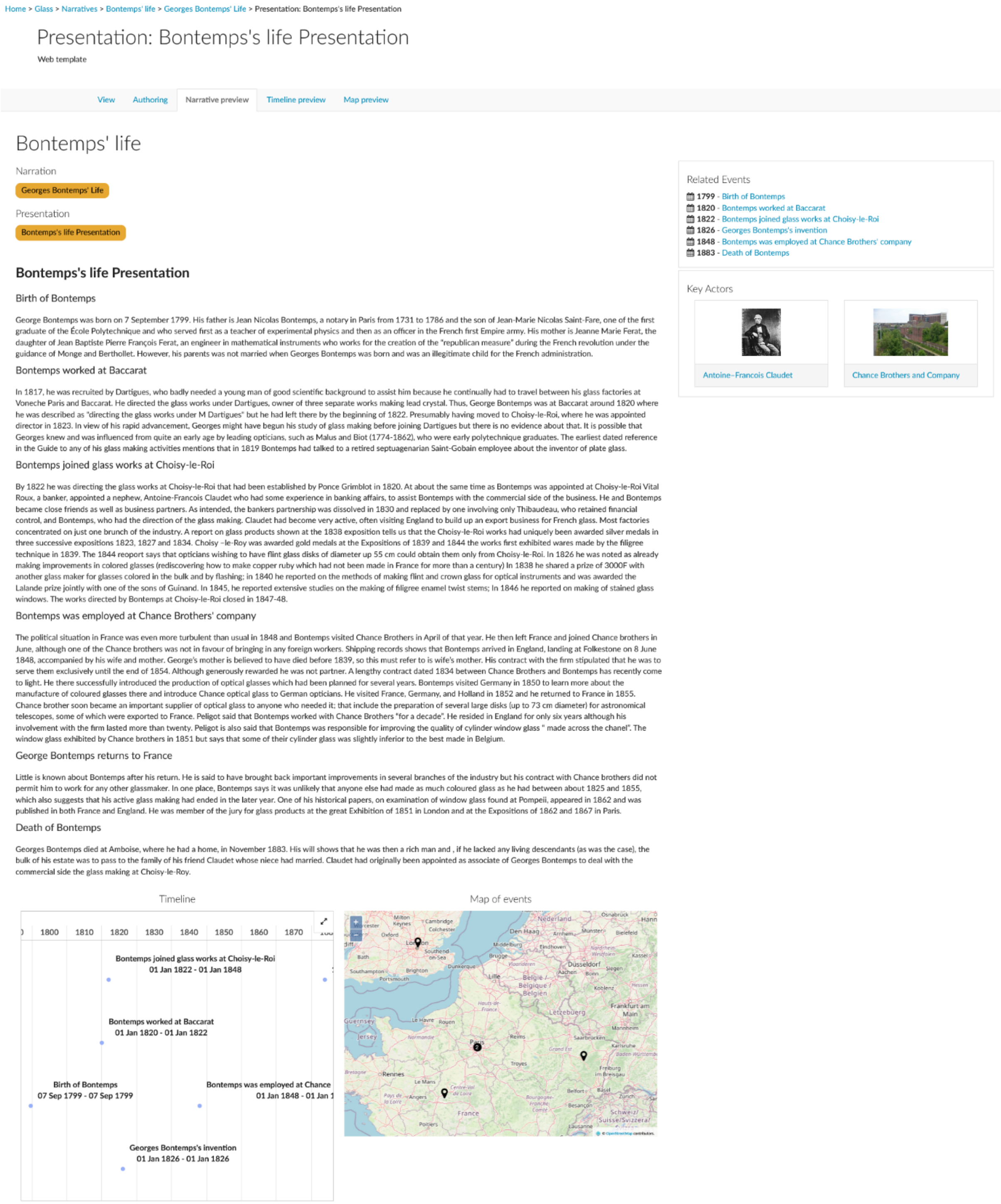

Figure 17. Web-based preview of the presentation

The narration titled "George Bontemp's Life" represents the academic interpretation of his life story by the experts of the CNAM. As shown before the Narration is further analyzed in the form of a Presentation which is medium and audience-specific. The presentation that we use as an example in this work, regards the web-based presentation of his life as shown in Figure 17.

9.8. Lessons learned

In this work, we have explored the wealth and depth of information that stems from the various manifestations of tangible and intangible CH. In this exploration, it was from the beginning apparent that this wealth is both an opportunity and a challenge. The opportunity arises from the multitude of ways that this wealth can be exploited with technical means to support information, education, and training. The challenge stems from the fact that a systematic process is required if we envision bringing order to the chaos of the available information and information sources that constitute both the social and historical context but also the making dimension of each CH subject.

Towards this direction, we started defining a cross-disciplinary methodology that could support the systematic study of a CH element. We learned that only through the collaboration of experts from multiple disciplines we can reveal and record the multitude of dimensions and in this process, we identified issues in terminology methodology and understanding. The process attempts to systematize terminology and enforce a common understanding by defining commonly accepted activities across its pipeline. This provides the basic building blocks for executing the initial steps of the process of collecting the required information and digital assets.

In the process of representing knowledge stemming from multiple dimensions and disciplines, we understood that more expressive power is required to support semantics on top of knowledge elements. There is a need for a knowledge model that encodes the semantics of the CH element and connects it with its social and historical context through a collection of events that formulate a time-space continuum. Positioning the CH element in time and space allows us to generate narrations that tell a story that people may relate to and thus enhance its value. At the same time through an abstraction of processes, we can support the representation of generic recipes as forms of instructions that contribute to the representation of the make dimension. The result of this learning process was the implementation of a semantic model that can represent the aforementioned information and an authoring platform to make this expressive power available to knowledge curators and ICT and data scientists.

The execution of the aforementioned steps allowed us to generate a knowledge set capable of supporting the building of further knowledge in the form of narratives and descriptions of processes. We understood that from such descriptions several presentations may occur as these translate the represented knowledge in different ways by facilitating the technical tools provided by each presentation modality. The rich set of use cases presented in this chapter are examples of such presentation variations.

9.9 Conclusions

In this chapter, we presented a systematic methodology to support the representation of CH elements. This representation adheres to existing knowledge standards of the CH sector and supports systematically the documentation of the CH element including the social and historic context at the period of its existence and the make dimension of its creation. To this end, we have created the definition of the process, the allocation of roles, and a common terminology to support the collaboration of multi-disciplinary experts. The process is supported by an online authoring platform (MOP) that systematizes its application. Finally, out of the achieved representation we have presented the building of alternative presentations scenarios and modalities. We strongly believe that the achievements of this work can be extended to support even richer representations and at the same time can be adapted outside the CH context since top-level exploitation of knowledge is generic enough to support a plethora of application contexts including formal and informal education, vocational training.

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