care, judgment, dexterity

CRAEFT

Enhanced Ethnographic Methods

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Executive summary

This deliverable outlines the Craeft methodological approach, aiming to understand and document craft-making processes. It draws on various disciplines and emphasizes the intangible aspects of craftsmanship. The document is structured in 5 main sections: Introduction, Protocol, Representative Crafts Instances, (RCIs), Data Collection, and Conclusions. The document also includes a glossary organised by disciplinary approach and an appendix on the mechanical characterisation of the RCIs.

After an introductory section, Section 2 presents the Craeft Ethnographic Protocol, which aims to improve ethnographic documentation using digital tools and interdisciplinary collaboration. The protocol systematically documents traditional crafts, emphasizing the preservation of skills and knowledge. It categorizes digital assets and knowledge into craft practice and craft context, providing a flexible and adaptable approach for comparative studies across diverse contexts. The interdisciplinary rationale behind the protocol involves collaboration between Social Sciences and Artificial Intelligence, as well as contributions from various other fields. Inclusive collaboration with craft communities is promoted, addressing gender biases and ethical considerations for participants. The protocol's interdisciplinary approach aims to enhance understanding of craft processes through different data collection methods, encompassing operational sequences, professional biographies, tacit knowledge, and practitioner motion.

Section 3 unfolds Craeft RCIs exploring diverse craft practices across Europe, focusing on glassblowing in Nancy; tapestry weaving in Aubusson; woodcarving in Yecla; porcelain making in Limoges; marble carving in Tinos; silversmithing in Ioannina; traditional pottery and textiles in Crete. These crafts are deeply rooted in their respective cultural and historical contexts. Through interdisciplinary collaboration and comparative perspectives, Craeft seeks to foster dialogue and understanding among diverse gestural expertise while preserving and safeguarding Europe's rich craft heritage.

Section 4 focuses on data collection and analysis in craft ethnography, the document addresses diverse data types, file management, visual annotations, event parsing, and event logging. These methods aim to comprehensively capture and analyse the crafting experience within social, historical, and sustainability contexts. A closing section reflects on Craeft Ethnographic Protocol for putting into dialogue the realms of ethnographic research and artificial intelligence, fostering a transformative dialogue. It integrates pragmatic ethnographic exploration with formalistic computational methodologies to deepen understanding of craft practices. This cohesive approach leverages the strengths of both disciplines, prompting innovation and challenging preconceptions. Beyond theory, the protocol's practical impact extends to educational institutions, reshaping skill transmission in vocational schools, fine arts institutions, and museums. Preserving cultural nuances and oral traditions aligns with UNESCO's framework for safeguarding Intangible Cultural Heritage. This holistic approach reflects the essence of ethnography, emphasising experiential knowledge and the dynamic nature of cultural practices.

In Section 5, conclusions are drawn on how this research can aid the preservation and study of traditional crafts in Europe.

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Abbreviations

AR	Augmented Reality
CAP	CRAEFT Authoring Platform
CH	Cultural Heritage
CHI	Cultural Heritage Institutions
CrO	Crafts Ontology
GDPR	General Data Protection Regulation
HCD	Human Centred Design
HCI	Heritage Computer Interaction
ICH	Intangible Cultural Heritage
IPR	Intellectual Property Rights

MET	Material Engagement Theory
MoCap	Motion Capture
MoU	Memorandum of Understanding
NLP	Natural Language Processing
NURB	Non-uniform rational B-spline modelling
OCR	Optical Character Recognition
RCIs	Representative Crafts Instances
TCs	Traditional Crafts

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1. Introduction

This deliverable outlines the ethnographic approach developed within the Craeft project and its various lines of action. One of the main objectives of this project is to develop methodological, technological, and analytical tools to deepen our understanding of crafts-making processes and refine their documentation. As craft practices are complex and encompass multidimensional realities, covering a wide range of both tangible and intangible dimensions, the disciplinary strategies for their study are also manifold. Thus, the ethnography of craftsmanship developed in Craeft draws on specific contributions from Anthropology, Cognitive Sciences, Art History, and Physical and Computational Sciences, among others, that address different aspects of crafting activities. At the core of this interdisciplinary network is the ethnographic protocol for documenting and recording gestures, which reflects the major attention that Craeft gives to the intangible dimensions of know-how.

Enhancing ethnographic methodologies implies not only accompanying disciplinary methods, expertise, and technological devices, and bringing them into dialogue but also rethinking and updating the specificity of their role in understanding crafts-making processes. This deliverable therefore includes an overview and a reflexive synthesis of the role of ethnography, its methodological tools, its postulates, and its references within the scope of the Craeft project

To provide some guidelines, this document is addressed to the whole spectrum of individuals, social groups, organisations, or institutions, interested in the study, documentation, preservation, and transmission of traditional craft practices, be they researchers, scholars, practitioners, craft educators and heritage professionals, policy makers, etc.

Field ethnography [1] identifies and describes the activities of social groups and their members as visual and “textual reconstructions of reality” [2]. Ethnographic sciences aim to understand the experiences, behaviours, beliefs, values, and social representations that articulate human activities. First and foremost, field ethnography is a method of data collection used to capture the ordinary activities of informants (their emic point of view) that includes specific strategies to avoid personal biases and possible instrumental slants of the ethnographer in the data collection exercise (his/her etic point of view). It involves immersing oneself in a particular setting, such as a community or organisation, and collecting data through different observation practices, and interviews. Observing from the inside, or participant observation as a way of working, enables the production of knowledge that develops during direct, practical, and sensual engagements with our environment [3]. From this point of view, researching artisanal embodied practices implies an encounter with craftspeople in a process of mutual learning. Working with craftspeople implies learning with and from them. Participant observation thus becomes a process through which ethnographers learn to perceive a craft, educate their attention, exercise judgement, and become engaged and involved with it. In an itinerant or wayfaring fashion, craft ethnography is a way of learning-as-you-go [4].

Craft workshops have been the subject of study for certain digital ethnography approaches [5] [and these techniques have been applied, for example, to carpentry [4], glassmaking [6] [4] and textile manufacturing [7] [7]. Building on these approaches, the Mingei project (2018-2021) has given us the first opportunity to formalise the collection of data and knowledge for craft practice and propose ways for its documentation. This effort led to the outline of a model to semantically and multimodally organise this knowledge and its digital assets, following international standards adopted by the Cultural Heritage community. For Mingei,

the craft instances have been represented in a phenomenological way, both verbally and visually. This mode of representation addressed both tangible and intangible dimensions of craft and contained representations of craft practice. This representation involved the crafting processes and their plans. It was then implemented by semantically representing the physical entities and actions that take place during the fabrication of craft products. Physical entities were verbally represented by descriptions of the events associated with semantic annotations from thesauri. These representations were associated with recordings of the events, as well as digitisation of the tools involved and the produced artefacts. However, this model did not contain a mechanical description of the recorded phenomena as well as a description of the environmental stimuli that the practitioner attends to. These descriptions would be useful because they can provide a deeper and more detailed description of the actions of the practitioner. They, furthermore, enable the simulation of the physical events that take place, which is important for training as well as the materials and energy economy of training. Moreover, they are important because they can provide potential clues on how human creativity and actions work.

To improve the ethnographic documentation of crafting processes this deliverable focuses on the following topics:

1. A methodology for documenting craft-making processes as “the unit activity attended by a practitioner” [8] that involves a description of the action that leads to the transformation of materials into craft products.
2. The use of digital technological tools that can assist the work of the ethnographer.

As outlined above, the collection of this information and knowledge requires the interdisciplinary collaboration of a wide range of experts. In this deliverable, we strive to formulate an interdisciplinary approach to the collection of this information, combining ethnographic sciences facilitated by the capabilities of digital sensors and media: the Craeft Ethnographic Protocol.

2. Craeft Ethnographic Protocol

2.1. From the UNESCO guide to Mingei

In 1990, UNESCO released a guide aimed at facilitating the data collection process for documenting traditional crafts [9]. This comprehensive guide outlined essential elements to be recorded, including artefacts, materials, tools, and the intricate actions involved in crafting. The methodological approach it advocated emphasised systematic data gathering and thorough processing, encompassing practical knowledge, techniques, and the nuanced status of the artisan [10].

In 2003, UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage (ICH) served as a new framework for the protection and preservation of traditional crafts. This category recognizes the significance of skills and techniques that are transmitted from generation to generation within communities. The aim is to safeguard and promote the diversity of such skills, ensuring their continuity and relevance in contemporary contexts. Within this convention, the "traditional craftsmanship" category acknowledges that certain skills, techniques, and know-how are integral to the identity and cultural heritage of communities. These skills often involve various forms of craftsmanship, including artisanal techniques, craftsmanship associated with specific trades, and other forms of traditional knowledge related to tangible and intangible cultural expressions. The inclusion of traditional craftsmanship in the convention underscores the importance of preserving not only the end products of craftsmanship but also the skills and knowledge embedded in the processes. This recognition highlights the dynamic nature of traditional skills, which evolve and adapt while retaining their essence. By safeguarding traditional craftsmanship skills, the convention seeks to foster a conducive environment for the transmission of knowledge and expertise. This involves supporting educational initiatives, encouraging intergenerational learning, and promoting the viability of traditional crafts within contemporary social and economic landscapes.

Built on this new category, Mingei [11] proposes a first protocol for representing the ICH of traditional crafts, offering practical tools for its implementation. This first protocol provides a systematic approach to collecting and organising digital assets and knowledge about ICH. It involves the creation of a formal model that can be effectively utilised for research, education, and preservation. Accompanying digital tools facilitates the online curation of craft representations, aligning with contemporary digital practices. Within the suggested framework, knowledge about crafts is categorised into two primary domains: craft practice and craft context. Craft practice encompasses the intricate actions, tools, and materials involved in transforming raw materials into refined craft products. This category extends beyond the tangible elements to include aspects such as the education and training of practitioners, tacit knowledge acquired through experience, material preparation recipes, and the optimal sequence of process steps—elements that may not be readily observable during a practitioner's work. Craft context delves into the historical, traditional, and contextual facets of the craft. This includes exploring traditional motifs and aesthetics embedded in craft products. The knowledge acquired in this category allows for a nuanced understanding of the variations in materials, aesthetics, and local histories across different communities, highlighting the richness and diversity of traditional crafts.

Then [12], the focus shifts to the modelling of crafting processes, emphasising that these processes often involve decision points, alternate workflows, and the coordination of parallel or combined activities by one or more individuals. Some steps are dedicated to handling exceptional events, such as rectifying

mistakes or addressing accidents. This approach is embraced in modelling crafting processes using activity diagrams, ultimately transforming them into interlinked semantic knowledge entities.

2.2. From Mingei to Craeft

The development and implementation of an ethnography-rooted research protocol stand at the core of this initial project, serving as a focal point for this deliverable's primary objectives. The Craeft Ethnographic Protocol considers the unique configuration of the project, strategically tailored to address its diverse methodological requirements. Designed with flexibility in mind, the protocol is adept at accommodating the specific demands of various local crafts, catering to the nuanced needs of potential researchers who will apply it.

Crucially, the protocol's robust nature ensures continuity across different craft instances, allowing for seamless transitions from one context to another. This intentional design is driven by the overarching goal of ensuring the applicability and transferability of the protocol. Its adaptability extends beyond the inherent diversity of each craft instance, encompassing the array of technologies employed in the documentation, recording, and representation of artisanal gestures.

A key emphasis lies in the comparative basis of the project. The protocol serves as a unifying framework, facilitating the systematic comparison of various craft practices. This comparative approach not only enhances our understanding of individual crafts but also contributes to the broader goal of elucidating shared elements, techniques, and cultural nuances that transcend specific contexts. In essence, the protocol acts as a linchpin, fostering a comprehensive and comparative exploration of artisanal gestures across diverse craft instances and technological applications.

2.3. Interdisciplinarity rationale

The enhancement of ethnographic methods for the understanding of craft activities is based on collaborative efforts of interdisciplinary co-creation. This entails not only a structural dialogue between two primary realms of knowledge production—namely, the Social Sciences and the disciplines associated with Artificial Intelligence development—but also draws rich insights from the theoretical and methodological contributions of several other disciplines. These diverse areas of expertise play a crucial role in shaping the project's approach and methodology.

Anthropology contributes foundational principles to understanding the sociocultural dimensions of craft practices, delving into human behaviour, cultural practices, and contextual factors influencing craft-making. Artificial Intelligence disciplines provide technological advancements, utilising tools for data analysis, pattern recognition, and innovative approaches to document and understand craft processes. Material Culture Studies play a vital role in understanding the significance of materials, tools, and artefacts in the crafting process, shedding light on tangible elements shaping the final product. Theoretical frameworks from Art History offer perspectives on intentional and creative aspects, examining aesthetic choices, the design process, and the impact of design decisions. Engagement with the Sociology of Technology explores the dynamic relationship between craft and technological advancements, studying how technology influences craft practices and vice versa. Insights from Cognitive Science aid in understanding mental processes involved in craft activities, encompassing aspects of skill acquisition, memory, and decision-making. Cultural Studies contribute by examining broader cultural contexts in

which craft activities are situated, exploring how cultural factors influence the evolution of craft traditions and practices. Human-Computer Interaction (HCI) principles are integrated to enhance the usability of technological tools, ensuring an intuitive and effective interface between human craft practitioners and technological applications.

Through this multidisciplinary approach, the project aims to create a holistic understanding of craft activities, integrating technological advancements with cultural, social, and cognitive dimensions.

2.3.1. Cognitive sciences

The relationship between attention, sensory stimuli, and craft actions is an interdisciplinary topic that spans cognitive psychology, neuroscience, and the arts. When we engage in craft activities, our minds need to focus attention on relevant sensory information to perform tasks effectively.

Insofar as the project aims to study the mechanisms by which tacit knowledge can be cultivated and transmitted, cognitive sciences have a crucial role to play in this project. Cognitive scientists are to develop targeted observations and interviews to describe the craft elements, in an explanatory fashion, coping with the challenge of identifying and describing sensory, tacit, and intellectual insights. Moreover, we rely on this discipline to obtain insight into how the mind exploits and focuses attention on sensory stimuli that are relevant to the craft action in hand. Cognitive processes contribute to the intricacies of craft [13] like the role of imagination, the cognitive structures involved in craft problem-solving, and the interplay between language and action. It also helps us to think about the relationship between cognitive processes and the regulation of human performance [14]. The way attentional mechanisms influence and regulate cognitive processes during the performance of complex tasks such as crafts offers a nuanced understanding of how cognitive regulation intertwines with performance in artisanal practices. Cognitive sciences also explore the concept of flow—a state of optimal experience where individuals are fully immersed and engaged in an activity [15]. It investigates the conditions that lead to the flow state, describing how certain activities can bring about a sense of deep enjoyment and fulfilment. Delving into the psychological aspects of optimal experience, it provides insights into how individuals can achieve a state of flow and enhance the quality of their lives. The field of Action Science [16, 17], focusing on the study of human actions and their cognitive underpinnings, also provides insights into the theoretical frameworks and methodologies that contribute to the understanding of actions, emphasising the integration of cognitive science and psychology. Finally, the concept of embodied cognition [18], sheds light on the understanding that cognition is not solely a function of the brain but is deeply intertwined with the body and its interactions with the environment. Our cognitive processes are shaped by our bodily experiences, emphasising the role of perception, action, and the environment in shaping thought, highlighting the inseparable connection between the mind and the body in cognitive processes such as crafts.

2.3.2. Physics and material sciences

The intersection of physics, material sciences, and traditional crafts is a fascinating area that explores how understanding the properties of materials and physical principles can enhance craftsmanship and the development of traditional techniques. Physics [19] and Material Sciences [20, 21] assume pivotal roles in advancing ethnographic methods for studying crafting activities. These disciplines offer indispensable insights into the physical and material dimensions of craft elements, fostering a profound comprehension of the underlying principles that govern craft actions.

Physics emerges as a key player by unravelling the intricate physical principles that dictate crafting processes. It provides a lens through which the forces, energies, and material behaviours inherent in crafting activities are comprehended (D3.1). For instance, it elucidates the physics behind the manipulation of materials, the application of forces, and the dynamic processes involved in creating specific configurations [20]. This knowledge is fundamental for grasping the scientific intricacies of shaping materials, contributing to a nuanced understanding of the physical aspects of crafting.

Material Sciences, on the other hand, goes deep into the properties and characteristics of materials employed in crafting (see Appendix). This discipline scrutinises material composition, strength, elasticity, and plasticity, offering a comprehensive understanding of how these properties influence the crafting process and the outcome [21]. Such insights are invaluable for optimising material selection, ensuring the quality of crafted products, and exploring innovative material possibilities within craft practices.

The collaborative synergy between Physics and Material Sciences establishes a robust scientific foundation for enhancing ethnographic methods and enabling a holistic grasp of crafting activities. It allows researchers to delve into the intricate relationships between physical phenomena, material properties, and the craftsmanship involved. Consequently, it elevates the depth and breadth of ethnographic studies in the realm of crafting, fostering a richer appreciation of the artistry inherent in creating tangible artefacts [19].

2.3.3 Computer and information sciences

Computer and information sciences play an increasingly important role in the ethnography of craft by providing tools, techniques, and methodologies to enhance various aspects of research, analysis, documentation, and communication within the field. Being a tool that served other disciplines, computers play multiple roles in ethnography, providing solutions in data management, documentation, digital imaging and MoCap, cataloguing and classification, as well as Natural Language Processing (NLP), for the transcriptions of interviews and conversations. Specifically, Natural Language Processing plays an important role in the transcription of speech into text, using the technology of Automatic Speech Recognition [22, 23]. Computer vision is also of use in the analysis of videos of practitioners at work, helping to understand the techniques and skills involved in crafts [24]. This can be particularly useful for educational purposes, allowing students to learn from masters even if they are not physically co-located.

Central in Craeft are information scientists who must model craft elements as knowledge classes [25]. This modelling process is instrumental in structuring and categorising diverse components of crafts, including materials, techniques, tools, and cultural contexts. Within this framework, action plans are formulated as generative hypotheses, serving as strategic outlines for achieving specific craft-related goals. These action plans are dynamic and flexible, allowing for diverse outcomes, and are crucial in simulating "mental images" [26]. The simulated "mental images" provide a conceptual representation of the expected outcomes and are interconnected with the knowledge classes established during the modelling phase. This interplay allows for a dynamic understanding of the craft domain.

The modelling process is iterative, with continuous refinement of knowledge classes based on feedback from craft practitioners who engage with the action plans. This iterative nature ensures that the model evolves, capturing the complexities inherent in the craft domain.

Beyond the simulation of outcomes, the generative hypotheses and refined knowledge classes play a significant role in informing decision-making within the craft domain. Craft practitioners can leverage this structured information to make informed choices regarding materials, techniques, and processes, contributing to the advancement and innovation within the craft field.

2.3.4. Ergonomics

Ergonomics is a discipline that emphasises the optimization of systems to enhance human well-being and integrates principles from various scientific domains, including psychology, biomechanics, engineering, and physiology. A such, it can also be useful to enhance craft ethnography. Rooted in industrial engineering, it focuses on efficiency workplace design, and human-tool interactions for optimal performance and safety. This involves biomechanics, investigating the mechanical aspects of the human body in various activities to optimise postures, and movements, and reduce the risk of musculoskeletal disorders.

As such, ergonomics has developed its methodologies and theoretical concepts, focusing on real work activities [27] pointing out the relevance of developing a perspective tailored to each professional activity. Ergonomics research has a twofold objective to contribute to the field of knowledge of situated human activities while participating in the transformation of the real world [28] which includes a prospective orientation. The ergonomic perspective is concerned with everyday situations as well as those linked to work or training. It aims to understand these situations through the analysis of the activity and to do so to contribute to transforming the situations [29]. The instrumental approach [30] was developed within the framework of ergonomics research within the French context. This approach is conceived as always situated and proposes a series of concepts that allow us to understand situations of instrumented activity. The instrument is distinguished from the artefact and constitutes a mixture of interiority and exteriority since it is both subject and artefact: a material or symbolic artefact produced by the subject or by others, and an associated pattern of use resulting from the subject's construction or the appropriation of social patterns already formed outside the subject [31].

2.3.5. Art History

Craft ethnography can draw on art history to contextualise and understand the aesthetic and symbolic dimensions of craft production. Historical perspectives can help in tracing the origins, development, and transformations of craft traditions over time. As ethnologists focus on the comparative and analytical study of cultures and their customs, historical contextualisation contributes to understanding the cultural variations and traditions that shape craft practices.

However, it must be noted that, in recent decades, in the field of art history, there has been a renewal in the ways of studying artistic or craft production, emphasising not only the symbolic dimensions or the historical significance of artworks or artefacts but also the creative and making processes as well as their materiality [32, 33, 34, 35, 36]. The reconsideration of handwork, craft practices and artisanal activities within art history demonstrates the close relationship between the making of craft objects and the making of art objects while redefining the hierarchy of cultural value. Craft is not understood as a defined practice but as a way of thinking through practices of all kinds [37]. Art history has been profusely impregnated with some approaches and key ideas that emerged in the context of the so-called “material turn” that took place within the social sciences. These perspectives are intended to overcome the "mind vs. hand" dichotomy that still dominates most studies of artistic practice being open to finding useful approaches

outside the field of art history [34]. This renewed interest in art history and the materiality of artistic practices has led to the foundation for a material-based art theory sensitive to its technical aspects [38] Connected to this, certain interdisciplinary research strands have appeared or have expanded, such as the technical art history [39] which, in addition to an exercise in reflexivity on the material conditions that make the artistic act possible, offers multiple points of connection with other disciplines within the social sciences. Thus, the scientific analysis of the materiality of artworks has developed into a strong and interdisciplinary division of art history and could stimulate a (re)-turn to a more process-based approach for the discipline [34]. In this context, research and pedagogical initiatives that explore the intersections between artistic making and scientific knowing [40], should be highlighted.

2.3.6. Heritage studies

The role of heritage studies and museology should also be highlighted when reflecting on the processes of institutionalisation of cultural practices such as craft. In particular, the development of heritage devices and protocols, such as Intangible Cultural Heritage (ICH), their potentialities and limitations, has been the subject of extensive debate and critical evaluation that can inform and complexify ethnographic practice. Some of these analyses have focused on understanding how this heritage category is constructed, taking a critical look at the issues and problems it raises as well as its possible socio-cultural effects [41]. These perspectives explore how ethnology can help us to understand international heritage policies, from their definition in a global arena to their application in a multiplicity of geographical and cultural contexts [42]. The role of ethnographers' skills and methodologies for the effective transmission of diverse cultural practices is also addressed [43]. As an interdisciplinary field, heritage studies also have much to contribute to the understanding and development of creative solutions to the social, economic and ecological problems that arise as a result of conflicts between different value systems and their associated frictions in contemporary societies [44]. Some of these lines of reflection have focused on the role of heritage discourse in the process of its constitution and functioning as well as its modalities of use [45]. Reflecting on how heritage operates, and its changing perspectives allows us to understand that heritage is not necessarily about the stasis of cultural values and meanings, but can equally be about cultural change [45].

Heritage studies also engage with the intricate dynamics of cultural preservation, transmission, and representation. It delves into the multifaceted layers of meaning embedded in cultural practices, emphasising the need for their safeguarding and promotion. In parallel, museology, as the study of museums and their role in society, plays a crucial part in shaping the narratives surrounding cultural heritage. Museums often serve as custodians of cultural artefacts and practices, contributing to the dissemination of knowledge and fostering a connection between the past and present. Discourses around ICH from the point of view of ethnographic practice foster a more comprehensive and nuanced understanding of the intricate relationship between cultural practices, heritage studies and the changing landscape of museology. In contemporary contexts, challenges arise at the intersections between heritage, crafts, and tourism. The tourism industry and the global interest in sustainable craft productions linked to fair trade challenge assumptions about the separation between industrial practices and craft productions. Many artisans working with traditional or common practices face the challenge of negotiating heritage expectations and economic survival. Moreover, beyond the preservation of threatened craft practices, heritage policies must also address their future cultural, environmental, and economic sustainability.

The 2003 Convention for the Safeguarding of the Intangible Cultural Heritage recognises the "importance of the intangible cultural heritage as a mainspring of cultural diversity and a guarantee of sustainable development" [46].

As the Convention normatively implies, ICH is a 'driver' and an 'enabler' of development, relating to the paradigms of sustainable development and human development [47]. The links between ICH and sustainability as a notion informing Sustainable Development as a policy field are increasingly relevant in a rapidly changing context [48]. Sustainable development priorities influence representations of the ICH. These connections expand the boundaries of the heritage realm and challenge conventional assumptions about the social uses of heritage [49].

The recent history of the craft sector spans the decline in production volumes, replaced by industrial production over the last century, to its resurgence in recent decades, driven by new markets and the increased interest of urban consumers. This re-evaluation of crafts and craftspeople involves highlighting their ethical, environmental, and socio-cultural aspects, linking them to sustainability and increasing their perceived value. Traditionally, crafts have been considered environmentally friendly because of their scale of production, and the use of renewable materials. Its reliance on manual skills and human energy as well as the fact that handmade objects often have a long lifespan and timeless designs, promotes environmental sustainability and the development of the rural economy. As a relatively new concept, sustainable craftsmanship emerges as a response to hyper-efficient production and consumerism. Its transformative aim contributes to the shift of societies towards sustainable and ecologically sensitive configurations, which include a connection to locality, systemic thinking, and authentic notions of self.

2.3.7. Material culture studies

Material culture studies focus on material objects and their meaning and examine how material objects are used to communicate ideas, values, and beliefs. Craft ethnography can draw on material culture studies to understand how craft objects are used to express identity, create community, and communicate meaning. Although issues of materiality pervade a wide range of disciplines in the social and human sciences, this field of study unifies the various approaches to material culture and gives them an institutional identity [50].

As such, Material Culture as a field of research in the ethnography of craft, is related to the resurgence of the deconstructionist turn in verbal analysis. It offers a counter-perspective by exploring the sensual dimensions of objects, challenging the predominantly visually based theories, and considering the evidence of all senses. It also expanded beyond the conventional approach of active subjects creating passive objects. It explores how materials can alter individuals, become integral to identities, and delve into various aspects of object-subject relations. Focusing on the fluidity of process, practice, and performance, material culture studies acknowledge the transformation of both objects and individuals by reviewing modes of collection, exchange, display, and preservation of objects, linking them to power struggles and intellectual property rights.

Strongly influenced by anthropology, objects biographical approaches [51, 52, 53] have been developed and theorised within this field of study, providing a methodological and analytical framework for material culture research. Following the individual journeys and processes of objects highlights their changing status and brings to light aspects that would otherwise remain hidden. This consideration of objects as subjects of biographies [54] and the focus on how their life is articulated around specific events implies

paying particular attention to the material becoming of objects while deploying a specific analytical approach to making processes.

2.3.8. Archaeology

Archaeological methods can be applied to study historical crafts, ancient techniques, and the evolution of craft practices over time. Experimental archaeology [55, 56, 57, 58], as the investigation of archaeological issues using experiments, has been part of archaeology from the very beginning of the discipline [59]. It is a multifaceted approach with numerous fields of application. As a relatively recent academic discipline within the social sciences, through different methodologies, experimental archaeology seeks to understand how human groups used to carry out their activities. Through experimental reconstruction of artefacts, uses and techniques, experimental archaeology generates and tests hypotheses on the feasibility of past societies in various tasks or feats. The approaches of this discipline and its methodologies oriented towards the reconstruction of past material actions can be linked to the history of technology and the material sciences. Archaeology-based experiments investigate activities that might have happened in the past using the methods and materials that would have been available. Experimental archaeology can aid interpretation by giving comparative data and providing the means to evaluate different archaeological techniques or the most efficient way to recover data showing how natural processes affect the formation of archaeological sites. This approach can relate to a wide range of different artefactual or eco-factual materials and demonstrates the value of “actualistic” experimentation within archaeological science, and how such experiments can be integrated into much broader programmes of research [60].

Material Engagement Theory (MET), a new theoretical framework from cognitive archaeology [61] that is aimed at studying the human mind in both historical and contemporary contexts, can also be very helpful for craft ethnography. MET comprises three fundamental tenets. Firstly, cognition is perceived as extended and enacted, where material forms are considered integral components of the mind, and cognition manifests through the interaction between brains, bodies, and these material entities. Secondly, materiality is attributed to agency, signifying its ability to influence changes in both brain processes and behaviours. Finally, meaning or signification emerges actively through the engagement with material forms. This theoretical approach provides an archaeological framework that not only redefines the nature of cognition but also establishes the archaeological record as an intrinsic element of the cognitive process. Crucial concepts within the framework of MET can help the ethnography of crafts. "Metaplasticity" is one such concept, suggesting that the plasticity of the human mind is intricately embedded within a malleable material culture. Additionally, the concept of "thinging" underscores the idea that humans engage in thinking through and with material things, emphasising the symbiotic relationship between cognition and materiality [62].

2.4. Inclusivity rationale

Engaging the community is a core aspect of the Craeft protocol, necessitating cooperation and a willingness to share best practices. Collaborating effectively with Cultural Heritage Institutions (CHI), associations, communities, or individuals involved in the craft under study demands a well-defined framework and a shared understanding among partners. Establishing institutional communication and comprehending the collaboration goals are initial steps, involving the exchange of contact information and logistic details. This phase also requires identifying the legal representatives of the involved partners.

2.4.1. Inclusion

Craeft starts from the premise that practitioners should have a central role and be involved in the research process itself. The project is based on co-creation practices including experienced craft practitioners and instructors from different spheres of craft activity, as the main source of knowledge. The selection of the craft instances displays and highlights the diversity of craft practices which constitutes a valuable research feature of the project's approach (section 3).

Considering the unequal social dynamics and the gender biases that are deeply rooted in traditional crafts, Craeft is committed not to perpetuating fixist representations. One of the levels at which these genders are visible is the realm of language. Gender issues are deeply embedded in the very vocabulary used to socially constitute professional practices as well as to describe them. Craftsman, and craftsmanship, are just some of the possible examples. Aware of these biases, Craeft develops gender-sensitive practices and makes use of gender-neutral terms, e.g., craftspeople. From the point of view of social history and within a comparative perspective, some techniques that in a certain geographical context were linked to one gender, in another context were associated with another gender. For example, in the case of weaving techniques, in Germany, as a proto-industrial technique in the 17th century, it was carried out by men, the same techniques in Greece, during the same period, were carried out by women. Craeft uses the presentation of contextualisation narratives to show that gender roles in the same craft were different at different locations. Although traditionally some of these craft practices were practised by one gender only (e.g., marble carving has traditionally been male), training structures increasingly welcome students of all genders. This trend should be amplified, with a view to the future, as strategies for the preservation of these techniques require the renewal of their practitioners regardless of their gender. This gender-inclusive perspective leads to the creation of new communities of craftspeople.

2.4.2 Co-creation

This phase entails obtaining an initial comprehension of the craft under investigation, in collaboration with practitioners. The strategy involves engaging in workshops designed to facilitate interaction with craft communities, fostering a participatory approach in defining both the craft practice and its broader contextual framework. Through active involvement in these workshops, researchers aim to establish a foundational understanding of the studied craft. This understanding is not only limited to the technical aspects of craft practice but extends to encompass the broader cultural and historical context in which the craft is embedded. It serves as a crucial preparatory step before delving into more detailed ethnographic activities. Practitioners play pivotal roles in these workshops, contributing their expertise and insights. The collaborative nature of these interactions allows for a co-creation process, where the knowledge and perspectives of both researchers and the community are mutually integrated.

2.4.2.1. Understanding

The workshops are organised preferably at or near the workspaces of craft practitioners, to be able to demonstrate the identified concepts. If this is impossible for part of the participants, teleconferencing facilities can be employed.

In terms of craft practice, practitioners explain and identify workspaces, actions, processes, tools, materials, and anticipated results, such as end craft products, treated materials, etc. Practitioners also explain the qualities of materials, as well as the way that these are perceived through the senses. In

addition, they convey the criteria to judge the successful completion of actions, as well as the methods to correct mistakes done during the crafting process. The workshops are complemented by targeted interviews with community members, particularly to explain subjective insights (for craft practice) and narratives that convey traditions and collective memories of local communities.

In terms of craft context, communities explain a community's history and social context and the traditions followed within and along with craft practice. Typical topics include a timeline of craft history, representing its origins, its technical evolution, as well as its aesthetic evolution in terms of art history. This is conveyed by a collection of narratives and reference artefacts that illustrate and contextualise the expression of a craft over time.

2.4.2.2. Craft vocabulary

One of the project's aims is to create a craft vocabulary. Central to the development of this craft vocabulary is the systematic identification of key categories within each craft domain. By delineating these categories, we lay the groundwork for a structured approach to terminology development, allowing us to delve deeper into the nuances of each practice within different linguistic contexts, focusing on cultural and regional variations that shape each language of craftsmanship. By embracing diversity and inclusivity, we ensure that our vocabulary resonates with practitioners across borders and boundaries.

Within these categories, we compile an extensive list of terms used in each craft. From the tools wielded by artisans to the materials they shape and manipulate, every term is meticulously defined, offering clarity and insight to practitioners at every level of expertise. Organization is also key to the efficacy of this craft vocabulary. Whether alphabetically arranged or categorized according to craft discipline, a logical structure ensures accessibility and ease of navigation, empowering practitioners to locate the information they seek with efficiency and precision. The generation of the vocabulary is achieved in collaboration with practitioners — whose first-hand experience enriches our understanding and informs our terminology.

The main references for this dataset are the Getty and UNESCO thesauri, however, additional references may be obtained from national thesauri. Moreover, the vocabulary is multimodal, in the sense that each term is explained both verbally and visually.

The verbal basis of this vocabulary is the nouns and verbs required to describe the manufacturing process. In addition, adjectives are required to describe qualities and perceptual properties. Each vocabulary entry is associated with digital assets that illustrate and exemplify it, as well as with a reference to its semantic definition in a thesaurus. Nouns and verbs are used to describe crafting concepts and tasks. Nouns regard physical items, such as artefacts, materials, work sites, protective clothing, machines, and tools used in crafting actions. Verbs regard the actions performed during craft practice. Adjectives refer to perceptual qualities that describe the way that artefacts and materials are perceived.

The visual part of the vocabulary is images and videos. Pertinent images and videos are available from a multitude of open online sources (e.g., Wikipedia, YouTube). The visual examples for the vocabulary are then to be complemented by the ethnographic recordings.

The multilingualism of this vocabulary is important for two reasons. The first is to be accessible to persons of multiple languages. Up to this end, the Getty thesaurus offers translations in a wide range of languages. The second is that practitioners may have local expressions and terms for the vocabulary entries. The

latter entries are identified and defined in collaboration with the community of practitioners in the workshop.

2.4.2.3. Scenario

This task regards the work required to prepare the ethnographic recording sessions. This task is implemented using a "scenario" giving details of the plot. The goal is twofold. First, to illustrate the decomposition of actions into simpler ones, so that for the preparation of the recording sessions. Second, it is to validate and improve this plan with practitioners, by collecting feedback on underrepresented properties and concepts.

Initially, a rough outline of the scenario is developed. We recommend the following adaptation of the so-called, "three-act structure" [63] for the scenario of the recording of each crafting action.

1. Act 1 — Setup: recording of tools, materials, and workspace.
2. Act 2 — Confrontation: recording of the interaction (negotiation) with the material that is transformed.
3. Act 3 — Resolution: recording of the outcome of the action.

We call the recording of each action a "scene". The recording scenario for processes is the concatenation of the scenarios for each scene.

The next stage is to expand on the outline to create a detailed document that explains the purpose, goals, style, and approach for each scene. Using this document, the recordings are gathered and organised per modality.

2.4.3 Ethics and Legal

Given the integral involvement of human participants in the collaborative project, the utmost importance is attributed to ethical considerations and data protection. These components are not only pivotal for the project's success but are also fundamental in ensuring accessibility to the project's results. Fulfilling these aspects mandates obtaining approval from designated Ethics Committees.

Ethical considerations encompass a comprehensive evaluation of the project's impact on human participants. This involves adherence to the European Commission's ethics self-assessment guidance and the Ethics Appraisal Procedure, which provide frameworks for ethical assessment and approval.

Data protection, a critical aspect of modern research, is governed by the General Data Protection Regulation (GDPR) and additional national laws. Compliance with these regulations is imperative to safeguard the privacy and rights of individuals involved in the project. To foster a seamless and effective collaboration, a transparent agreement must be forged with Cultural Heritage Institutions (CHIs), associations, communities, or individual stakeholders. This involves a meticulous definition of the usage of Intellectual Property Rights (IPR) associated with digitisations, information, presentations, and knowledge generated throughout the collaborative project. Communication with a CHI, community, or association can involve a description of the physical assets and collections of these institutions. CHIs and craft communities often have curated material, already prepared in the form of literature, guides, brochures or even interactive multimedia presentations. Typically, CHIs have a catalogue of their items

and may digital collections, along with pertinent metadata. In initial communications, it is important to specify these assets, as potential sources for knowledge collection

The creation of a Memorandum of Understanding (MoU) becomes a pivotal step in this process, requiring the involvement of legal representatives from all participating parties (see Annex). The MoU, serving as a legal document, fulfils several critical purposes within the collaborative framework. Firstly, the MoU distinctly outlines the purpose and mission of the collaborative project. It provides a detailed exposition of the objectives, goals, and anticipated outcomes that all parties aim to achieve through their collective efforts. Central to the MoU is the explicit definition of Intellectual Property Rights management. This section delineates the ownership, usage, and protection of intellectual property resulting from collaborative work. It ensures a fair and mutually agreed-upon distribution of rights among collaborators concerning digitised materials, information, presentations, and knowledge. Additionally, the MoU offers a comprehensive overview of the project scope, indicating specific activities, deliverables, and agreed-upon timelines. This clarity aligns expectations and ensures that all parties share a common understanding of the project's trajectory. The roles and responsibilities of each party are clearly defined within the MoU, encompassing contributions expected from each collaborator, be it in terms of resources, expertise, or other relevant aspects. In anticipation of potential conflicts, the MoU may include provisions for resolution mechanisms. This ensures a predetermined process for addressing disagreements, fostering transparency, and minimising disruptions to the collaboration.

By establishing this comprehensive and legally binding agreement, collaborating entities lay a solid foundation for their joint endeavours. The MoU serves as a guiding document that not only aligns expectations but also protects the interests and rights of all parties involved in the collaborative project.

Individual partner requirements are also to be investigated as community members may belong to a sensitive population. It is important to consider that some practitioners may be of senior age. As such, individual requirements of sensitive population groups need to be considered and applied. These requirements regard both the ethics of engagement to members of this group, who may be suffering from age-related diseases and consideration of pertinent requirements in the design of project outcomes.

2.5. Protocol Rationale

The interdisciplinary perspective of the Craeft Ethnographic Protocol aims to improve the understanding of the different technical processes in craft work environments, generating comparable data and providing tools for their analysis. This strategy enables the collection of a standardised dataset of heterogeneous craft instances. This standardisation is a prerequisite for the comparative approach of the project, for the modelling of action and affordance (D2.1), and for the maker-material negotiation model (D2.2).

This ethnographic protocol allows framing craft representation, digital re-enactment, education and training interface, as well as design. It is intended to be applied in the context of each craft instance, helping to structure each "dataset" on a solid experimental basis, while providing a foundation for the correct development of the project’s technological tasks. Furthermore, it is conceived inclusively as it situates the artisans' experience at the centre of the craft understanding strategies. The centrality of the artisans' point of view runs through the different stages of this process.

This ethnographic protocol involves the convergence of different methodological approaches and disciplinary traditions within the Social Sciences and Computer Sciences.

Social Sciences are articulated based on three interrelated survey methods: Anthropology of Techniques, Sociology of Work and Ethnomethodology. This three-fold approach makes it possible to collect different dimensions associated with craft practices. Mobilising the tools of the Anthropology of Techniques involves observing and documenting the *chaînes opératoires* (operational sequences) and collecting the functional and structural data associated with the crafts people's technical actions. This perspective is complemented by conducting interviews to collect data on the life course of craftspeople, both at the individual and professional level, inscribing the technical actions in a context that allows the artisans to give them value and meaning. Finally, the setting of a series of ethnomethodology-inspired elicitation techniques allows the collection of verbal and emotional data triggered during the re-visioning of the capture of the operational sequences carried out by the artisans.

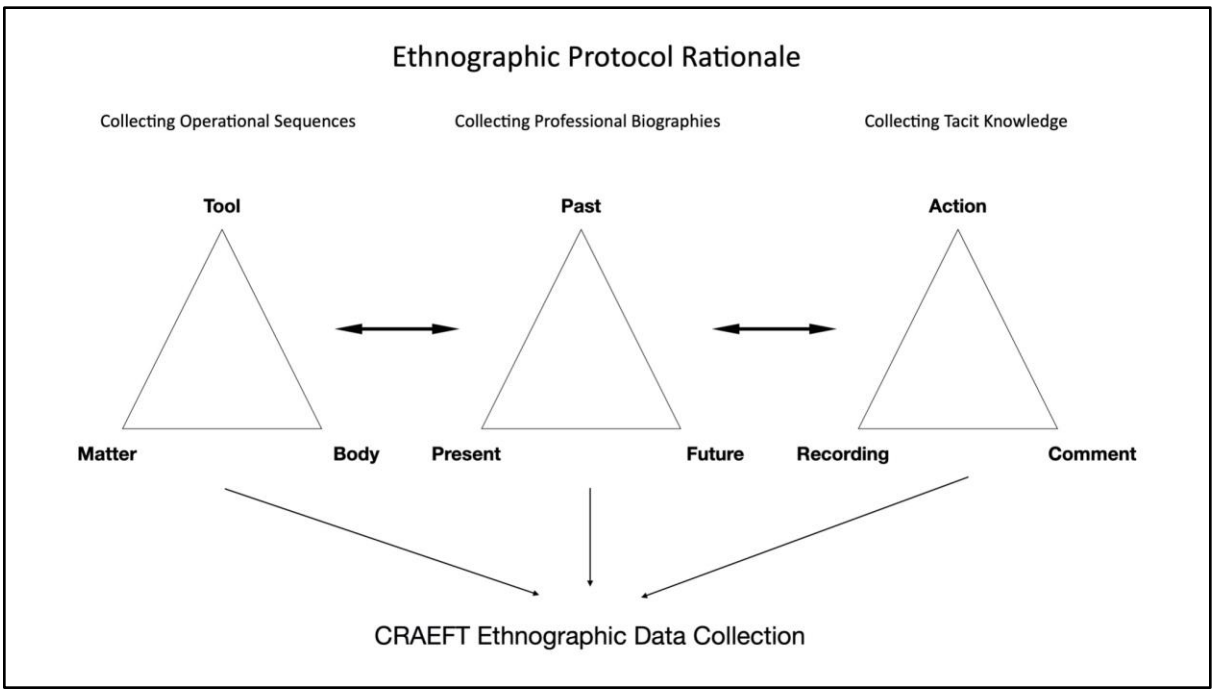

Figure 1. Craeft ethnographic data collection.

For the Computer Sciences, diverse modalities, such as images, video, and motion capture, play a pivotal role in the comprehensive data collection methodologies employed by the Craeft protocol. These modalities capture the intricate movements of practitioners, providing a nuanced understanding of their craft. Sensory recordings further enhance comprehension by documenting the non-verbal dimensions inherent in the crafting process. The digitization of material transformations emerges as a cornerstone in the protocol's approach, making substantial contributions to the documentation, analysis, and preservation of traditional crafts within their cultural and social contexts. The protocol goes beyond mere digitization, extending its efforts to encompass tangible entities integral to crafting—encompassing materials, tools, workspaces, and the final craft products. By digitising material properties, the protocol ensures a detailed and systematic representation, capturing nuances that extend beyond the tangible attributes.

The application of photographic and 3D documentation techniques, guided by stringent digitization standards, further solidifies the protocol's commitment to a comprehensive representation of objects and workspaces. This approach not only facilitates a detailed understanding of the physical aspects but also aids in the preservation of the cultural and historical dimensions embedded in these crafted objects.

2.5.1. Operational sequences

To collect functional and structural data related to technical processes and to document technical craft gestures, the ethnographic protocol is anchored in the theoretical and methodological approach of the Anthropology of Techniques and makes use of its key notions and specific tools.

The French disciplinary tradition within this branch of anthropology puts particular emphasis on studying technical gestures as a means of understanding technical processes. The centrality of the role of the human body, bodily knowledge and bodily skills is fundamental to understanding its methodological approach. One premise of this discipline is the determination to overcome the duality between technology and society. Technique is thus regarded as a social fact, like any other, and must be situated within its context, at the confluence of the interactions that give it meaning [64]. Its emergence as a disciplinary field is connected to certain approaches developed within the framework of French ethnology during the 1930s. The notion of "techniques of the body" defined as "how, from society to society, men know how to use their bodies" [65] is crucial to address the corporeal dimension of technical practices. This approach highlights the deeply corporeal and gestural dimension of knowledge production and transmission. Within this theoretical framework, we are invited to think jointly about gestures and tools [66].

From this approach, a series of analytical and methodological tools are developed and implemented, most notably the “operational sequence” or *chaîne opératoire* [66, 67, 68, 69, 70, 71, 64, 72]. This methodological concept defined a technique as “made of both gesture and tool, organised in a chain by a true syntax, which gives operational sequences both their fixity and flexibility” [66]. The “chaîne opératoire” can be considered a tool for observing, describing and analysing technical processes. It can be described as an ethnographically based method aimed at documenting technical processes. It enables the visibility of the sequential and structural dimensions of technical activities [69, 71] and the fundamental relationality of artefacts, practices, and networks [72]. As a concept and a method, the *chaîne opératoire* has undergone a disciplinary bifurcation in archaeology and anthropology [64]. While its application in archaeology has led to the conceptualisation of a generalised model aimed at reconstructing past processes based on their material results alone, whether whole artefacts or traces left by the manufacturing process, in anthropology it refers to "a concrete occurrence of a particular technical process" [64]. In archaeology, it is used to reconstruct past technical processes based on the type of material analysed, while in anthropology, it is important to highlight its role in providing the ethnographic data required to analyse the relational complexity of human technical activities. In both disciplines, the main contribution of the operational sequence has been to divert attention away from the finished product and focus it on the processes [**Error! Reference source not found.**]. Within the discipline of anthropology, it shows a great diversity in the modalities of its application, standing as a highly polyvalent tool [68]. Thus, operational sequences can be understood as:

- chronological, processual, and sequential.
- series of operations that transform raw material into a product.
- series of operations involved in all transformations of matter (including our bodies) by human beings.

Drawing on this approach and its issues, methodologies, and assumptions, the Craeft project continues to focus on bodies, gestures, and postures to gain a better understanding of technical activities. To update the challenges, goals, and approaches of the Anthropology of Techniques by complementing it with other disciplinary expertise and technological devices.

The transition from considering the operational sequence as both a method and a notion to the decision to focus on a set of representative gestures within the recording protocol involves a nuanced exploration of the complexities inherent in studying craft-making processes. Initially, the operational sequence is approached as a comprehensive method for documenting various aspects of crafting activities. This method involves the meticulous documentation of sequential steps, providing a detailed account of the craftsperson's actions, tools used, and the transformation of materials. However, as the research progresses, the realisation emerges that not all gestures within an operational sequence carry equal significance in terms of understanding the essence of a craft. Certain gestures may encapsulate key elements of skill, cultural context, or craftsmanship that are crucial for a comprehensive analysis. Therefore, the focus shifts towards identifying and isolating a set of representative gestures that encapsulate the essence of the craft-making process.

It is of course worth notice that it is the artisans themselves who are uniquely positioned to choose and define these gestures. Empowering artisans to choose and define the gestures of their craft is crucial. They know it best, having practised it day in and day out. Their insights are invaluable for capturing the essence of the craft and preserving its traditions. This involvement also boosts their pride in their craft, recognizing their role as tradition keepers and innovators. It allows them to shape the craft's story and contribute to its evolution. Artisan-led gesture selection guarantees authenticity and accuracy because these gestures aren't just symbolic; they're practical and rooted in generations of know-how. By letting artisans lead, we maintain the craft's integrity and ensure its true essence endures.

This strategic decision is motivated by the need for a more focused and in-depth exploration of specific actions that hold profound meaning within the cultural and technical dimensions of the craft. By narrowing the focus to a set of representative gestures, the recording protocol aims to distil the richness of the craft-making process into key elements that can be thoroughly analysed, understood, and potentially replicated.

However, it's essential to acknowledge the instrumental boundaries and limitations associated with this decision. Focusing on a select set of representative gestures inherently involves a degree of abstraction, potentially overlooking the intricacies of less highlighted actions within the operational sequence. There is a risk of oversimplification, and it becomes crucial to strike a balance between depth and breadth in the study. Furthermore, the recording protocol's effectiveness in capturing the nuances of these representative gestures relies heavily on the chosen recording modalities, such as video, motion capture, and interviews. Each modality has its strengths and limitations, influencing the comprehensiveness of the captured data. Video recordings, for instance, excel in capturing visual details and overall scene understanding but may not capture fine-grained motion details as effectively as motion capture. Moreover, the protocol may encounter challenges in accurately representing certain intangible aspects of the craft, such as the artisan's tacit knowledge or the cultural significance embedded in specific gestures. The reliance on visual and auditory modalities might not fully capture the sensory and tactile dimensions of the craft-making process. The transition from the operational sequence as a method to the focus on representative gestures within the recording protocol is driven by a desire for depth and meaningful analysis. This shift is not without its challenges, as it necessitates a careful balance between abstraction and specificity. Understanding the instrumental boundaries and limitations of the chosen

recording modalities is crucial for refining the protocol and ensuring a comprehensive exploration of craft-making processes.

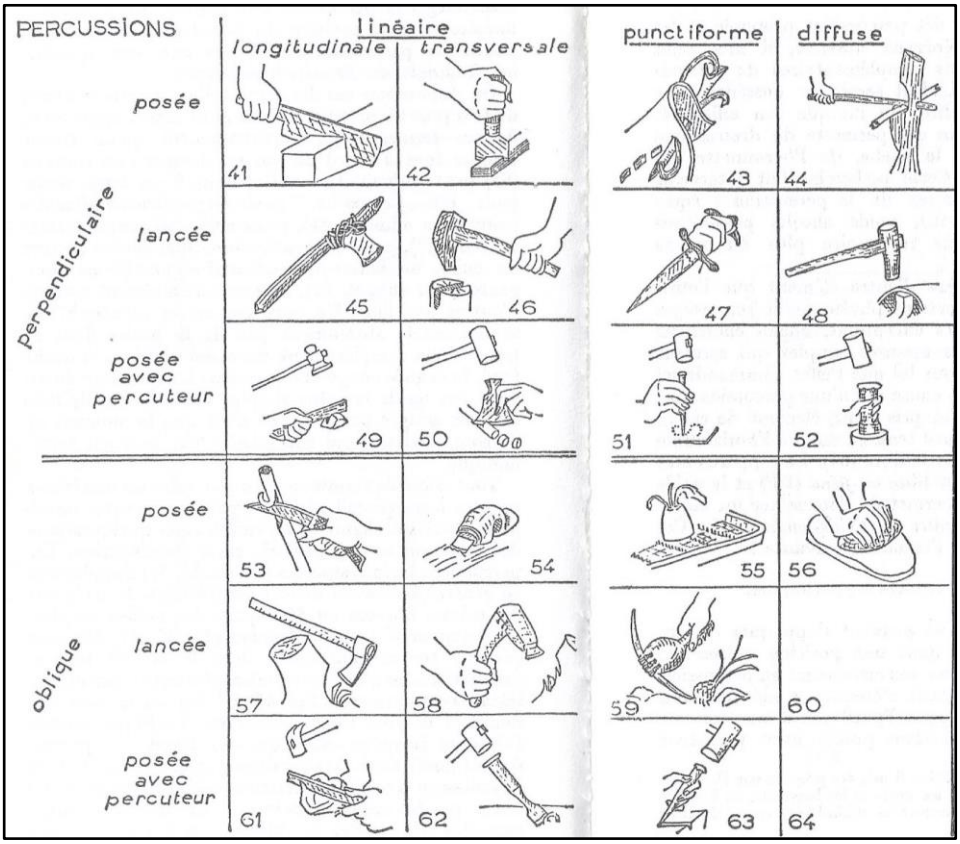

Figure 2. André Leroi-Gourhan, L'homme et la matière, 1943.

2.5.2. Professional biographies

In parallel to the collection of functional data on technical activities, conducting interviews with craftspeople focusing on their biographies allows us to give context to professional practices and to inscribe them in their singular trajectories. In this way, collecting data on the different training paths, and the succession of life and professional stages of the craftspeople sheds light on the processes of knowledge acquisition, their modes of transmission, as well as on the relationship between the practitioners and their professional practices. Bringing a "life course perspective" to the analysis of craft practices allows us to understand and put into context the overlaps between their technical and social dimensions.

This perspective involves using the "life course approach"[73] as a mode of inquiry to collect individual and professional data of the craftspeople. The life course approach is a conceptual framework employed in the field of Sociology of Work to analyse and understand individuals' career trajectories and experiences across the span of their lives. A "life course" is defined as "a sequence of socially defined events and roles that the individual enacts over time" [74] or as a sequence of "positions" of a particular person over time [75]. A "position" can have a big impact on a person's life and includes not only education or employment factors but also personal events or changes in social status. Life Course Theory (LCT) focuses on the impact

of age, relationships, life transitions and events, social change, and other choices on people's lives over the life cycle [76]. Work and employment as fundamental determinants of social mobility and societal behaviour have played a central role in the development of this theoretical approach. LCT has been the leading perspective driving longitudinal studies of human behaviours and associated economic and social outcomes [75]. To explain the divergences observed in the human development of individuals, associated with this theory is the development of the notion of "human agency" [77]. While the life course is determined by historical influences that shape education, family and career patterns, individuals also have the power to modify these outcomes. The core principles of life course theory are historical time and place, the timing of lives, linked or interdependent lives, and human agency [77].

As all life choices are contingent on the opportunities and constraints of social dynamics and culture, this approach involves thinking holistically about lives and development over time and across changing contexts [77]. As a methodology, it provides a framework for understanding the shaping of professional biographies within a broader life course context. The life course approach is a sequence of socially defined events and roles that an individual and professional enacts over time. The life course approach is about time, context, process, and meaning of individual and professional development. The life course approach reflects on the interaction between social and historical factors and personal and professional biography. It provides a unique overview of the meanders of life and work pathways, considering the interweaving of personal and professional changes and transitions. LCT defines a common field of inquiry by providing a framework that guides research matters of problem identification and conceptual development. The life course intersects with studies of work and organizational policy around the concept of 'career' [78].

Applying the life course approach to the study of embodied craft practices involves examining how individuals' engagement in craft activities evolves, influenced by various life events, transitions, and social contexts. This approach involves collecting individual and professional life courses of the informants through semi-structured interviews. Based on an analytical approach based on long-term temporality, this methodology makes it possible to articulate the relationships between past, present, and future. Therefore, some examples of questions conceived from this temporal approach would be: *How do you become a craftsman? What is your daily routine*? *How do you foresee the future of your craft*?

2.5.3. Tacit knowledge

The third methodological component of the ethnographic protocol aims to collect the personal and emotional data linked to craft practices. This is implemented using video elicitation techniques that allow to make explicit the tacit knowledge of professionals.

The elicitation techniques as methodological tools are associated with various approaches within the Social Sciences. The tradition of Ethnomethodology is crucial to understanding them. Ethnomethodology [79] is a sociological perspective and research approach that focuses on the study of how people make sense of their everyday social interactions taking into account the methods that human beings use in their daily lives to go to work, make decisions, engage in conversation with others and so on. Ethnomethodology is concerned with the practical methods individuals employ to accomplish social actions and how they are held accountable for these actions within specific social contexts. As a strongly context-sensitive approach, it makes use of the notion of a "social setting" which can be defined as an organised framework or environment for the activity, comprising rules, procedures, guidelines, distribution of parts of the activity and accountability resources [80]. As a discipline, it is characterised by the particular attention paid to detail, especially in the Ethnomethodology of Sciences [81].

Ethnomethodology is a primarily descriptive discipline and relies on the detailed description of situated activities to gain an 'in-depth' understanding of how people do what they do. This implies the use of a particular type of description [82] that is sensitive to the relevance of the details for those who carry out the activities. Within ethnomethodology, several studies have focused on work situations and have proposed a strong link between ethnomethodological analysis and intervention in the field [83]. *Accountability,* a central notion in Ethnomethodology, has been the subject of reflection within work situations. In particular, the ethnomethodology of professional activities has contributed to the opening of important research perspectives. There are two main lines of development in Ethnomethodology as a disciplinary field, namely conversational analysis and studies of work. Studies of work have developed rigorous approaches to documenting professional practices using video recordings, combined with the development of precise methods of analysis. This work pays particular attention to the perspective of practitioners, to the specific way in which they do what they do, and to the experience they have of what they do when they do it [80].

The use of video elicitation techniques within Craeft is informed by the methodological, theoretical, and analytical contributions of these research approaches. This mode of research is based on the use of images to express meaning: the meaning of the activity, the meaning of the situation, the meaning of the work, and to do this, using images to stimulate the spoken word. This way of using images to bring out the meaning of the activity and the situation for the actors, or operators, and more generally to bring out a discourse on the work which, for various reasons, proves difficult; this production of discourse and meaning is generally fed back into the analysis, which is enriched by an additional analytical layer [84].

The protocol focuses on a specific set of professional gestures selected by the craftsperson. The aim is to collect verbal descriptions of technical acts with video recordings and non-directive interviews. It involves confronting the practitioners with the video-recordings of their gestural activity in progress. Using the video elicitation interview allows us to collect verbal data on non-verbal actions and their personal and emotional dimensions. Based on a structure based on the triad action, recording and comment, practitioners are invited to describe their actions, their gestures, and their intentionality. The self-confrontation interview method [85, 86] re-immerge the practitioners in their activity by confronting them with the recorded gesture [87], triggering comments on intentions, goals, and decision-making processes. This approach considers the uniqueness of each gesture and the degree of gesture variability. Video elicitation interviews prompt discussion of subject-object interaction in detail because participants re-experience or re-live the activity while watching themselves working. Video elicitation interviews are about verbalization and wording of activities and associate a verbal description with the recall of thoughts, beliefs, and emotions experienced during the activity.

2.5.4. Practitioner motion

Conventionally, the record focused on the actions performed by practitioners. Their digitisation is possible through multiple modalities such as audio, video, and motion capture. In this work, we add the effect that practitioner actions have on the treated materials and the transformations that materials undergo due to these actions. The motivation for this addition is to better understand the effort of the practitioner and the result of each crafting technique.

Furthermore, in this work, we also focus on recordings of the sensory outcome of events. That is, we are interested in capturing the visual, audio, or haptic stimuli in the environment and which practitioners pay

attention to. In this way, we aim to better understand the decisions that practitioners make while working as well as the knowledge they employ during their practice.

2.5.4.1 Images

When activities are considered, such as crafting actions, carefully selected photographs can serve as "keyframes". When sequences of keyframes are juxtaposed in temporal order, they trigger visual perception to "interpolate" the motion between them [88], in this way conveying the recorded motion or event. The selection of appropriate keyframes requires insight and judgement, to select the most indicative and educational ones. The selection of the camera viewpoint is also important in producing informative keyframes.

Although keyframe sequences were a necessity before the proliferation of video recorders, the effort placed upon their selection serves an additional role. Keyframe sequences can be used to convey craft actions. Specifically, keyframes are systematically used in the creation of practical instructions relevant to body movement and actions, in a wide variety of contexts, from the assembly of furniture and electronics to safety instructions.

2.5.4.2 Video

Video analysis has been widely used given a few technical requirements. Video documentation of crafting actions and processes is used in craft ethnography, instructions, and documentaries [89, 5]. In [5], audio-visual recording tools are proposed both for the practitioner as well as for the ethnographer (notetaking). In some cases, ego-centric views [90, 87] are employed, using a worn camera to capture the viewpoint of the practitioner. Video dictionaries of crafting gestures were proposed in [91].

Ethnographic documentaries are designed to provide an overview, rather than a documentation of the craft. Recently, craft documentaries have focused on recording audio and visual stimuli of crafting scenes, to achieve better immersion in and understanding of the crafting workspace [4].

Recording from one or multiple fixed viewpoints has the advantage of minimising intrusion of the video recording equipment. A wide-angle lens is useful to be able to record the entire scene from a close distance. Practically, the camera is of a small size to be easily mounted at vantage viewpoints but also avoids getting in the way of practitioners. Fixed viewpoints are, thus, suitable for crafts that are exercised on a tabletop or workbench where all actions take place there and gestures are not (self)-occluded by the practitioner.

Active viewpoints, where the ethnographer chooses and changes the camera viewpoint at will, are the most informative because they exhibit the potential to capture the most informative view. On the other hand, they are dependent on the choice of the ethnographer. As such, multiple `takes", rehearsals and reviews with the practitioner are proposed to ensure that the information is indeed conveyed in the acquired video. Active viewpoints are valuable for the documentation of crafts that take place in more fine detail than tabletop settings, such as in sculpture and blacksmithing.

Egocentric videos are captured by a wearable camera, usually worn on the head or the chest. They exhibit the advantage of approximating the visual field and attention of the practitioner. They provide a valuable perspective in the understanding of the crafting activity [92]. They can be applied to virtually any type of

craft but on the other hand, they are not very well suited for crafts where an overview of the workshop is required. Such cases are encountered in crafts that involve moving to multiple parts of the workshop, e.g., glasswork, and where an overview of practitioner motion within the workspace is required.

Practitioner movements can be estimated from videos, using Computer Vision techniques. For the digitization of motion using video, markerless visual methods are employed. They are significantly less accurate than MoCap recordings and they require sophisticated algorithmic post-processing. Their application domain is wide but, like optical MoCap, they are also hindered by occlusions. As such they can be used in crafts that do not make use of large-scale machinery and they can also be used outdoors, such as in mastic cultivation and basket weaving.

2.5.4.3 MoCap

Motion Capture, also known as MoCap, is a technology used to capture and record the movement of people or objects and translate it into digital data. The process involves placing markers or sensors on the subject's body or object, which are then tracked by cameras or sensors to capture the motion. For craft practice recordings, the events of interest are practitioner postures and gestures.

Motion capture technology plays a pivotal role in precisely and comprehensively capturing the movements of craftspersons. Using suitable sensors or tracking devices, fine-grained gestures are recorded, allowing for detailed analysis. To ensure the ethical conduct of these recordings, key considerations include obtaining informed consent from participants and preserving the confidentiality of the captured data.

The process involves creating a sensor protocol that outlines the type of sensors to be used and their specific placement. This protocol also defines the characteristics of the recording, such as the gestures or steps of the routine to be captured. The placement of sensors is meticulously determined, considering the required positions to accurately capture the craftsperson's movements.

In practical terms, the recording phase includes capturing data from a diverse set of users, approximately 15, to ensure variability and a representative sample. Each user undergoes five repetitions of the recorded gestures. The recorded motion data is then segmented into meaningful units, considering temporal boundaries and the duration of each gesture. This segmentation provides a foundation for isolating specific gestures, facilitating in-depth analysis.

As an integral part of the analysis process, a gestural vocabulary is developed. This vocabulary serves as a tool for interpreting and analysing the captured motion data, enhancing the understanding of the intricate movements performed by craftspersons during their work.

The main types of MoCap techniques are optical and inertial. The choice of motion capture technique depends on the specific application and the requirements for accuracy, speed, and cost.

Motion Capture has been used to record and analyse practitioner motion in 3D. Multiview optical MoCap has been proposed to capture crafting gestures in 3D [93]. RGB-D cameras were employed in [94]. Inertial motion capture is used to accurately record articulated motion for crafting gestures in [95, 96, 97, 98]. In [99], motion capture was employed for both hands and tools.

The digital assets are 4D motion recordings, which we call “animations”. The applicability of MoCap and video modalities depends on the type of environment. For the digitization of motion using video, markerless visual methods are employed [100]. Albeit significantly less accurate than MoCap recordings, they require solely a camera and are the only way to treat archive video. Inertial MoCap is more suitable than optical in the cluttered space of workshops, due to reduced installation requirements and independence to occlusions.

Inertial MoCap is more suitable than optical in the cluttered space of workshops, due to reduced installation requirements and independence to occlusions. On the other hand, it exhibits a high degree of pervasiveness as a MoCap suit must be worn by the practitioner. This is a significant drawback in crafts that involve human touch and tactile sensing (e.g., pottery), as MoCap gloves obstruct the actions and sensations of the practitioner. Thus, they are suitable for crafts where delicate tactile sensations and motions are not required, such as in carpentry, metalsmithing, or sculpting.

Optical MoCap is significantly less pervasive as only markers are worn. This type of MoCap is more accurate than inertial, but the method is sensitive to occlusions and requires a setup that is available only for indoors and spatially constrained environments. As such, optical MoCap is suitable for crafts that are exercised indoors without the use of machinery that gives rise to occlusions, such as silversmithing, woodcarving, and knitting.

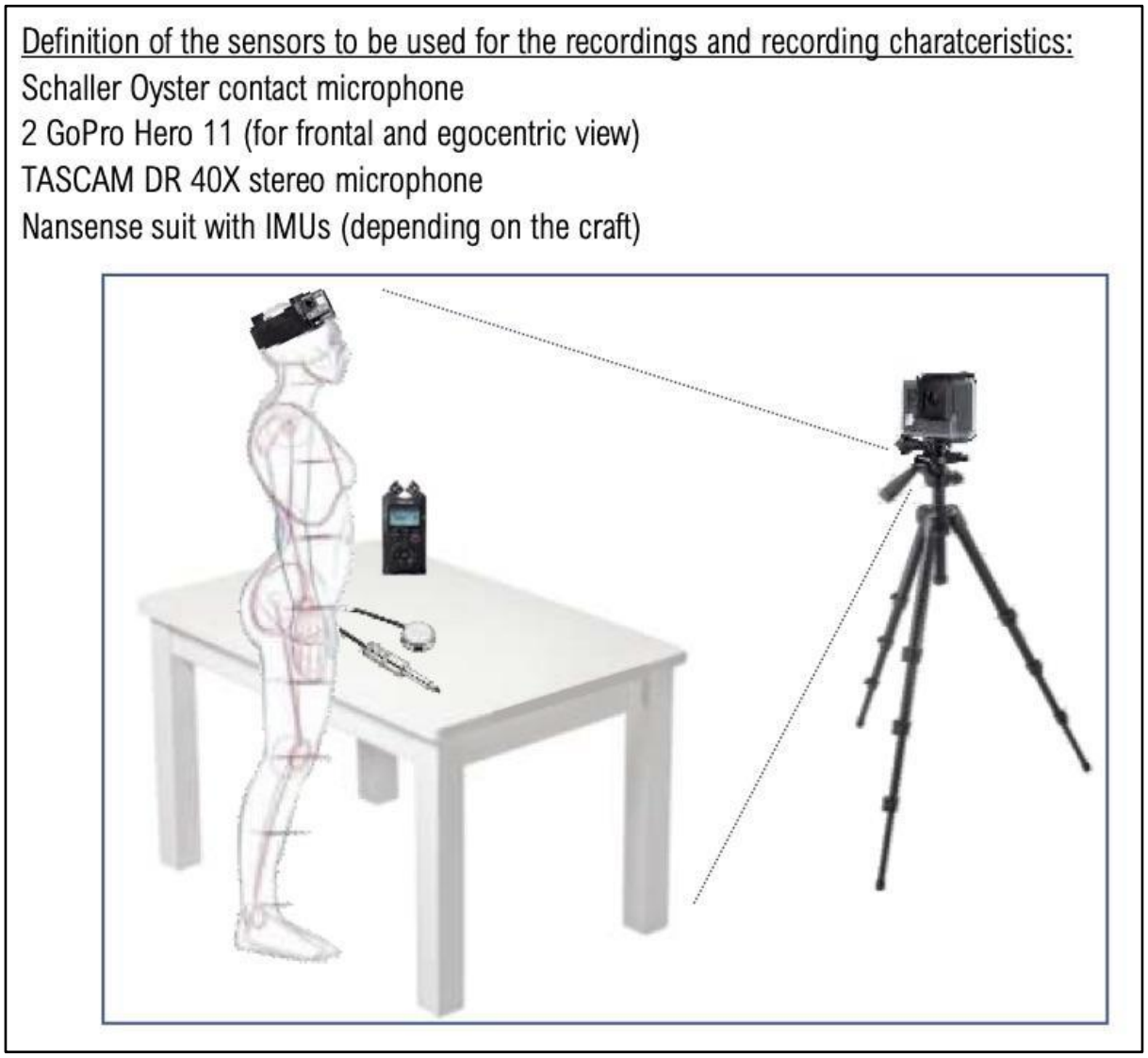

Figure 3. Sensors and characteristics for capturing practitioner motion.

2.5.4.4 Transformations

In crafting actions, the counterpart of practitioner movements is their results [101]. Thus, to better assess and understand this "negotiation" between the maker and the material [102], the digitisation of material transformations is proposed. In other words, we should capture the dynamic properties of materials under transformation into artefacts.

Digitising material transformations can provide valuable insights into the mechanics of the crafting process and help improve the quality of the final product. Digitising material deformation during a crafting process can be challenging but several techniques can be used, depending on the specific crafting process. The main approaches are the following.

Two-stage measurements regard the digitisation of structure before and after the action. This approach involves a 3D scanner to capture the structure of the material before and after the crafting action.

Depending on the material the 3D reconstruction can be achieved by a time-of-flight scanner, photogrammetry, active illumination, or other modalities to create 3D models before and after a crafting action. By comparing the two 3D models, the amount and location of material deformation are found.

Continuous measurements of deformation can be achieved through MoCap, strain gauges[1], and visual methods. Optical MoCap can be used by placing markers on the deformed material and analysing their movement. Similarly, strain gauges attached to the material directly measure the amount of deformation the material undergoes. These two methods are pervasive in that they require the placement of markers or hardware on the material and may not always be applicable.

Unobtrusive, continuous measurements can be obtained by purely visual methods. Direct measurements can be obtained by a depth or RGB-D camera. Alternatively, using conventional video, the deformation can be inferred through algorithmic analysis [103, 104]. However, in both techniques, the reconstruction is not full 3D but, instead, 2.5D as it is specific to the camera view. The difference is that 3D reconstruction models the objects in three full dimensions, whereas 2.5D reconstruction represents a scene from a single perspective, with information about the distance from the viewpoint to object points (a depth map); unlike 3D, 2.5D reconstruction does not provide information about "hidden" parts of objects for the given perspective.

The choice of technique depends on the specific crafting action and the desired level of accuracy. Given the proposed action taxonomy, two-stage digitisation of material transformation is recommended for works of certainty, which do not exhibit significant requirements in dexterity. In contrast, continuous digitisation of material transformations is recommended for dexterous actions, or work of risk, closely related to "free form" or plastic transformations. The reason is the requirement of closely associating human movements and tool uses with material transformations.

2.5.5. Objects and Materials

This section regards the digitisation of endurant, that is the tangible entities involved in the crafting process. These are the materials, the tools, the workspaces, and the craft products. The documentation of endurant entities is implemented with the digitisation technologies reviewed earlier. In addition to the conventional digitisation of objects, this work puts forward the representation of material properties. The motivation is to better understand the affordances provided by each material and its treatment by crafting techniques.

Craft artefacts are both made from materials, whose properties characterise both the end products as well as their treatment techniques. We distinguish between semantic and physical properties of materials.

2.5.5.1. Physical properties

This type of digitisation regards the physical properties of materials, which are relevant to the outcome of the material transformations occurring in a craft action [105]. The digital representation of the physical properties of materials has two aspects. The first regards the generic physical properties relevant to the transformation action exercised on the material and the conditions required for its success. The second regards properties that are relevant to individual pieces of materials, such as the veins in marble and the knots in wood [106, 107, 108]. Some examples of generic material properties and their relationship with crafting actions are provided below.

In the realms of blacksmithing and glasswork, understanding the melting and freezing points is paramount as they delineate the specific conditions under which craft products must undergo heating or annealing. Moving to stoneware, sculpting, carpentry, and woodcarving, the focus shifts to the crucial attributes of brittleness and stiffness. These properties play a determining role in establishing the force with which a piece of material can be handled without succumbing to breakage.

Transitioning to plastic crafts, exemplified by ceramics, the key considerations become plasticity and elasticity. These properties are instrumental in defining both the force and conditions necessary for the formation or deformation of material pieces. Notably, their significance is heightened due to their variable nature, influenced by external factors such as humidity [109].

Among these material properties, density emerges as particularly significant. This property holds sway over the weight and strength of materials, making it a fundamental aspect in various crafting endeavours.

A characteristic of materials is whether their properties are isotropic or not. Isotropic and anisotropic materials refer to the uniformity (or lack thereof) in the physical properties of materials in different directions. Isotropic materials have physical properties that are the same in all directions. Examples of isotropic materials are glass and metals. Anisotropic materials exhibit different physical properties depending on the direction in which they are measured. This directional dependence can arise due to the internal structure of the material, such as grain alignment, layered compositions, or other inhomogeneities. Examples of material anisotropies are marble veins and wood knots [110]. Such anisotropies are very relevant to the crafting process as the practitioner must consider them when performing a crafting process. Moreover, properties of individual pieces of materials regard properties specific to pieces or properties of materials. Material individualities are one of the reasons for the uniqueness of craft artefacts. The digitisation of individualities is not always simple, nevertheless, the photographic documentation and 3D reconstruction are powerful tools towards this direction.

2.5.5.2. Semantic properties

Semantic properties regard the naming of materials. These properties describe primarily the material name and secondary other information, such as material provenance, quality, as well as the method of production.

The naming of materials has multiple dimensions. The Getty Arts and Architecture Thesaurus [111] is adopted as a generic naming reference, which also offers translation in multiple languages. However, generic thesauri are not sufficient to entail more detailed naming of materials within the context of specific crafts, that represent different material qualities and compositions.

In many cases, legislation exists that regulates the naming of materials according to their composition of materials. For example, in the European Union, the material composition of threads determines the naming of the fabric type produced from them [112, 113].

The method of production of the material reveals qualitative characteristics that may determine its price, but also its compliance with ecological (green) and sustainability requirements. Like the naming of materials, such attributes may be subject to legislation and certificates [114].

Other semantic properties refer to the properties of materials that are relevant to the human senses, such as colour, tactile, and acoustic properties. Naturally, these properties are determined by the physical properties of the material, but they refer to felt properties. Some indicative examples are the colour of amber, the feel of satin, or the timbre of the oboe. Felt properties are referred to as "qualia" [115].

2.5.5.3. Recommendation

The mapping of material properties is an essential part of the proposed additions to conventional ethnographic methods. Ethnographic research, when extended to include the intricate details of material science, often raises ethical, legal, and regulatory questions.

The acquisition of material property data involves the utilisation of trusted material libraries like MatWeb[1] and ASTM[2]. These repositories serve as invaluable resources, offering a wealth of material properties and standards. MatWeb is a comprehensive material properties database, that provides a wide array of data encompassing physical, mechanical, thermal, and chemical properties. MatWeb facilitates material comparison based on properties, enabling informed decisions in material selection. Similarly, ASTM develops and publishes standardised testing methods and specifications. ASTM standards aid in material selection by offering guidelines and testing methods that ensure materials meet specific quality and performance criteria.

2.5.6. Objects and workspaces

Objects are the tools and machines used in the production of craft artefacts. The latter are the craft products, but also intermediate products created in the crafting process.

2.5.6.1. Photographic documentation

In the fields of archaeology, art history and museology, many recordings and examination methods are based on imaging techniques. The oldest and most central approach is photography. Photographic documentation has been conventionally used in the documentation of tangible heritage since the previous century. Photography has been recommended for the documentation of heritage, in general, and crafts in particular [9]. Photographs are essential in showing the appearance of craft products, but also the materials and tools of a craft.

Comprehensive guides in the photographic recording of CH artefacts and sites are [116, 117, 118]. Spectroscopic imaging methods provide insights into the chemical composition and physical properties of the materials and artefacts [119, 120, 121, 122].

A special case of endurant is information carriers such as books and manuscripts. Their primary digitization is photographic. Subsequent analysis regards the extraction of their verbal content conventionally through Optical Character Recognition as well as more advanced methods targeting manuscripts [123, 124].

[1] https://www.matweb.com/
[2] https://www.astm.org/

Photographic methods capture accurately the appearance of artefacts. Today, there are multiple types of photographic modalities used in a variety of domains from industrial inspection to forensics. To simplify the recording task, it is important to classify the imaging target as to its shape and material. We follow the Digitization Standards for the Canadian Museum of Civilization Corporation [125], which is an excellent reference for photographic documentation protocols, classified per the material and artefact type.

2.5.6.2. 3D documentation

The digitisation of objects and workspaces refers to conventional methods for the photographic and 3D documentation of tangible heritage. The 3D digitization of endurant regards structures of a wide variance of spatial scales, in indoor and outdoor environments. The choice of 3D scanning modality depends on the size, material, and environment type. For environments, this digitization may employ multiple scanning modalities, each operational on a specific scale. For example, rooms and outdoor areas require the combination of laser scanning and aerial photogrammetry to systematically cover. For smaller artefacts, photogrammetric reconstruction and active illumination sensors are nowadays simple and widely accessible. Comprehensive reviews of 3D digitisation technologies can be found in [126, 127, 128, 129, 130].

The field of 3D digitization encompasses a variety of techniques and modalities, each with its own set of distinct characteristics. 3D digitization, or 3D scanning, has attracted a growing interest in the documentation of structured scenes. Several 3D scanning modalities have been developed, which are distinguished as to whether they require contact or not with the scanned surfaces and objects. Non-contact scanning modalities are more widely employed, as they use light as the operating principle of the sensor. They can be further classified according to the sensor type, that is, into passive or active illumination systems. Active sensors emit their electromagnetic energy for surface detection, while passive sensors utilise ambient light.

The most adopted and robust principles for the digitization of tangible CH are time-of-flight or laser scanning, e.g., [131], structured light, e.g., [132], and photogrammetry, e.g., [133]. A range of products employs these principles in variations including digitisation over time [134]. In photogrammetry, terrestrial and aerial photogrammetry often differ, with the latter using the global positioning system (GPS) coordinates of the drone sensor to assist reconstruction. Combinations of these principles are found in off-the-shelf devices, such as the family of handheld scanners that combine trinocular photogrammetry with active illumination.

The capabilities of the available technologies vary in terms are resolution, accuracy, range, sampling rate, cost, operating conditions, skill requirements, the purpose of documentation, the material of the scanned object, as well as weight and ease of transport. Photogrammetric techniques provide more photorealistic texture than the time-of-flight modalities but are less accurate as to the structural accuracy. When accuracy is of paramount importance, close access to the scanned object is required. If this is impossible or impractical, aerial scans can be used. In this case, though, time-of-flight techniques provide less accurate results, if the sensor is airborne and, thus, not static. Hence, the sampling rate and scan duration of the sensor are relevant, as a time-of-flight scan lasts much longer than the acquisition of photogrammetry images.

These methods target the digitisation of objects and workspaces as historically significant artefacts and environments that need to be reconstructed in detail and with photorealism.

There are significant variations between the capabilities of different approaches. Triangulation techniques provide greater *accuracy* than time-of-flight but are reliable in short-range and difficult to apply in the field, due to the need for controlled illumination. 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 digitisation, concerning the overall time required for a scan.

The 3D ICONS Guidelines [135] is a comprehensive review of 3D scanning and processing guidelines. Important resources for 3D digitisation are available by Cultural Heritage Imaging[3], including tools, technology, and training, for several digitisation methods used in the conservation and preservation of tangible CH. The guidelines are not as apt as for photographic documentation, due to the wide complexity and variety of 3D scanning targets and the variety of modalities. Modalities vary in operational capabilities and environmental conditions, as well as cost. In some cases, the commission of the digitisation or rental of equipment may be more efficient.

Moreover, not all types of materials can be digitised using these methods. Artefacts made from challenging materials exist and require specific treatment. Challenging materials are those that exhibit specular, shiny, transparent, and translucent properties because conventional 3D reconstruction methods operate only for approximately Lambertian (matte) surfaces. Examples are glass artefacts and shiny metals. For their digitisation novel techniques are required. In the context of Craeft, we have developed two such techniques for transparent [136] and shiny materials [137].

2.5.6.3. Acquiring photographs and scans

The number of photographs required to reconstruct a target depends on the size and complexity of the target, as well as the detail by which the target should be scanned. At least 50 images are required to capture most of the details of a medium-size target, but the structural complexity of some targets could require hundreds of images to obtain an accurate 3D representation.

Acquiring as many angles as possible of the target is recommended. The first set of images should show the whole object, including ample portions of background so that the camera pose estimation required for photogrammetry is robustly estimated. Additional images can focus on detail. Each photo should overlap the last by about 60% or more. The overlap should be included between images of the first and second sets.

In outdoor terrestrial imaging, there are two main methods to acquire photographs. When working with planar or regular surfaces in application fields taking pictures by translating the camera is usually sufficient. For targets that require moving around the subject/scene is recommended. In indoor terrestrial imaging, it is important to take more images than outdoors to compensate for the lack of features and distance variability required for a robust camera pose estimation.

When aerial imaging is used the rules that apply are similar. If the target is the Earth's surface and the targeted model is a map-like representation, using the transitive camera motion as in the previous examples is recommended. The flight path should be grid-wise, as shown below. A second grid,

[3] https://culturalheritageimaging.org/

perpendicular to the first is recommended for increased reconstruction robustness. Overlap is recommended to be 80% or higher.

2.5.6.4. Manual modelling

Manual modelling refers to the creation of 3D models of tools and artefacts when it is difficult to do so using conventional methods. The 3D modelling of objects can be sufficient for many purposes pertinent to uses where the photorealistic reconstruction of an object is not of primary importance, such as in the modelling of tools to simulate and understand their role in the physical phenomena governing the transformations that materials undergo in crafting processes.

Manual modelling involves creating the model “from scratch” in 3D modelling software, such as Blender. The user can use various tools to create basic shapes, such as cubes, spheres, and cylinders, and then combine them to create more complex shapes. The basis of manual modelling is the spatial measurement of the objects so that their dimensions and shape are captured.

Polygonal modelling is the most common technique for creating 3D models. It involves dividing the object into a mesh of polygons, which are then connected. Non-uniform rational B-splines modelling (NURB) modelling uses non-uniform rational B-splines to create smooth, curved surfaces from 3D key points that the user defines. Finally, voxel modelling uses voxels to create 3D models treating voxels as “3D pixels”.

More recently, new tools have become available that use the metaphor of a painting brush to morph volumes into 3D shapes. The Blender sculpting tool is a powerful tool that can be used to create a variety of 3D models. It is a digital sculpting toolset that allows users to create and modify 3D models by pushing and pulling the surface of the mesh. It is a powerful tool that can be used to create a variety of objects, from organic shapes to hard-surface models. The Blender sculpting tool has a variety of brushes that can be used to create different effects. Some of the most common brush functionalities are smooth, inflate, deflate, crease, and grab (move).

2.5.6.5. Recommendation

A combination of the above methods is recommended depending on the target of digitisation, its material composition, and the purpose for which the acquired digital media are to be used. Specifically, all targets are photographically documented to capture their appearance conventionally.

3. Representative Craft Instances

The Craeft Ethnographic Protocol is implemented throughout diverse craft practices meticulously chosen as case studies by the Consortium. These practices, embedded in the European craft context, span across France, Greece, and Spain, each bearing its unique historical, cultural, and social nuances. The ethnographies, initiated in September 2023, are currently in progress and their evolving narratives are in the process of being documented and analysed. The complexity introduced by the diversity of these practices and their socio-cultural contexts enhances the intricacy of data collection, providing a multi-layered set of elements for analysis. The project's comparative perspective and its interdisciplinary approach seek to foster a dialogue among distinct gestural expertise. Despite the material-specificity of these craft practices, one of the project's aims is to delve into the commonalities, unravelling the material actions that transcend professional realms. For instance, an exploration into what marble carving shares with wood carving. The focus lies on understanding the shared corporeal engagement and the minute unfolding of technical knowledge in the dynamic interaction between material, tool, and body.

3.1. Nancy glassblowing

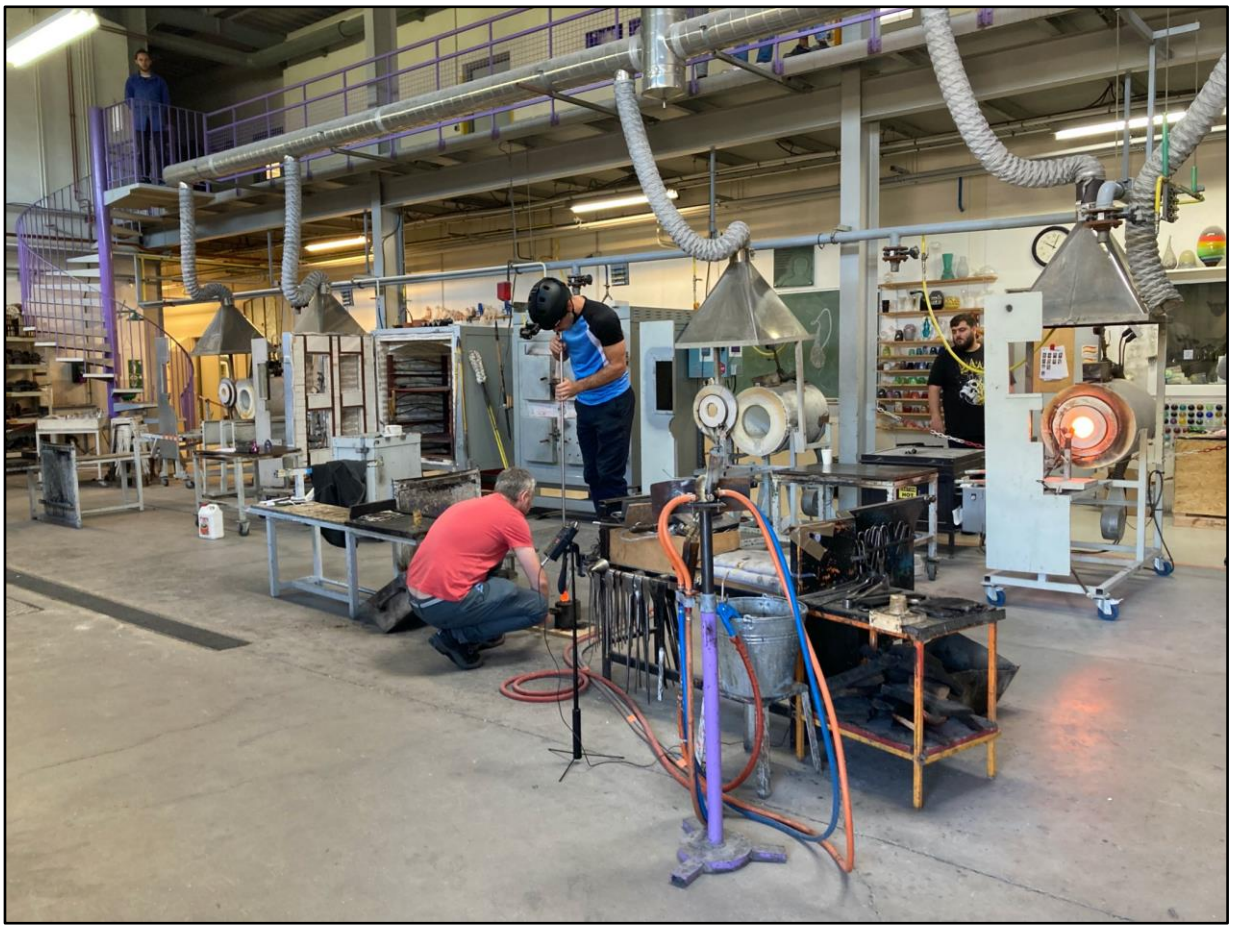

Figure 4. Nancy Glassblowing, September 2023 (image: Arnaud Dubois).

In December 2023, UNESCO announced the inclusion of "Knowledge, craft and skills of handmade glass production" on the Representative List of the Intangible Cultural Heritage of Humanity. These glass-working gestures and techniques are deeply rooted in the Grand Est region of France, boasting over 150 glass craftspeople and small to medium-sized enterprises, along with four major crystal manufacturers, cultural institutions and two training centres. In this local context, Cerfav is the only centre offering a comprehensive range of glass specialities in one location. Since its establishment in 1991, it has played an active role in preserving and safeguarding glass-working techniques through training, cultural mediation, research, and innovation.

The glassblowing techniques were the ones for which the Craeft consortium already had the most information, as we had previously worked extensively on this technique with Cerfav for the MINGEI project. Therefore, it seemed logical to start the documentation with this craft. Since we were familiar enough with this craft and the working context in the Cerfav workshop, we could empirically and for the first time test the different aspects of the Craeft protocol.

The recorded sequence of actions, selected by the glassblower we worked with, was the production of a glass tumbler. The choice of this object was influenced by the fact that an apprentice glassblower must be able to make this item to obtain his Professional Certification. Therefore, the making of this object incorporates the essential gestures that every glassblower must master. Additionally, the fact that the craftsman we worked with had completed the "glass creator" training (equivalent to a +2 level) at Cerfav before becoming the head of the public workshops in this institution allowed us to record a glassblower whose training was recent enough to explain us the challenges and difficulties of mastering these characteristic gestures.

The main methodological challenge during this initial recording session was related to the "video elicitation" aspect of the protocol. This part was indeed innovative from both an ethnographic and technological perspective (with the egocentric view), and we wanted to see if the craftspeople would endorse this documentation method, allowing us to replicate it in the other pilots. The experiment was largely positive. The glassblower expressed the novelty of the egocentric perception of his craftsmanship. Being able to see himself working from this point of view opened to him a whole new understanding of his expertise, particularly in the relationship between different parts of his body in action during the technical activity. The relationship between the direction of the gaze and the placement of the hands, the connection between the posture of the shoulders and the execution of the correct gesture – all this experiential knowledge became visible to him through this aspect of the protocol and allowed us to validate it.

This initial session also allowed us to experiment with the interdisciplinary collaboration between ethnographers and engineers and understand how ethnographic and technological aspects of the protocol interacted or not. One interesting aspect worth noting here is the question of camera positioning in the workshop based on the actions performed by the glassblower. Indeed, the ethnographer's knowledge of glassblowing and the Cerfav workshop allowed him to quickly guide the engineers to the correct camera placement for each step of the making of the tumbler. This ensured that the recordings used the most relevant angle possible to document the body in action and the interaction between the glassblower and the molten glass.

We also experimented with the question of temporality, bridging the extended time of ethnographic observation and the condensed time of technological recording. The session at Cerfav emphasised the essential need for ethnographic preparation before the recording session. Not adequately understanding the gestures and the craftspeople beforehand could pose a risk to the production of a strong data collection.

https://www.cerfav.fr

https://ich.unesco.org/en/RL/knowledge-craft-and-skills-of-handmade-glass-production-01961

3.2. Aubusson tapestry

Figure 5. Aubusson Tapestry, December 2023 (image: Thierry Caron).

Inscribed on the Representative List of the Intangible Cultural Heritage in 2009, the craft of Aubusson tapestry is exclusively practised in the Creuse region of France. This tapestry craftsmanship supports three manufacturers, nine independent master weavers, three paper template designers, and three dyers, thereby creating a significant volume of related work such as wool production, fleece washing, wool spinning, and tapestry restoration. A training centre, a museum, and various galleries complete this panorama. Thus, Aubusson tapestry uniquely benefits from having all stages of its production chain concentrated in the same isolated rural territory. This specificity drives the scope of this pilot.

According to the Craeft protocol, the weaver chose to record the "warping process" (the “passée” in French) as a typical gesture of the Aubusson tapestry craft. The "warping process" is a set of coordinated gestures performed by the weaver to create the fabric. Seated on a horizontal loom bench, the weaver separates with her hands the even and odd cotton warp threads by shifting their weight with her foot onto a treadle connected to it. Once separated, the weaver slides the wool weft threads between the cotton warp threads, from one hand to the other. The weaver then pulls on the wool thread to tighten it. The tension applied to the wool is felt by the weaver, who strives to maintain it consistently with each pass to keep the fabric flat. After the wool thread is passed between the cotton threads, the weaver uses a beater to bring the wool thread down and juxtapose it with the previous warping. The weaver places the beater between the warp threads, tilting it and giving quick downward strokes to bring the wool thread down. The gesture remains consistent with each warping to achieve the flattest fabric possible. Finally, after multiple warping has been completed, the weaver uses a comb to pack them together.

Given the centrality of the wool threads in this gesture, this choice provides a methodological opportunity for the protocol. It opens the deployment of extensive fieldwork in Creuse to contextualise this specific action within the entire Aubusson wool threads production chain. From the sheep's fleece to the "tombée de métier" (when weavers cut the warp threads to "release" the wool tapestry from the loom), this ICH achieves a local empathy with wool. Indeed, understanding the gesture of warping requires tracing the entire social life of wool threads and thereby questioning how sustainable development influences Aubusson tapestry craftsmanship. Wool, as a living material, fully aligns with the new concept of "sustainability" within ICH's notion of "living heritage". This connection between sustainable and intangible, both within and beyond "warping", will particularly implement the Maker-Material-Negotiation model (D2.2) with fine-grained ethnographical data to understand it.

From a technological perspective, the documentation of the warping process also allows us to produce a comparatist perspective on weaving with the “Cretan woven fabrics” case and the “silk” pilot of the MINGEI project. The documentation of the warping process will also be a good example to experiment with haptic technologies (D4.2).

https://www.cite-tapisserie.fr/en

https://ich.unesco.org/en/RL/aubusson-tapestry-00250

3.3. Yecla woodcarving

Figure 6. Yecla woodcarving, February 2024 (image: Inés Moreno).

The city of Yecla, located in the region of Murcia, is a centre of industrial furniture production. The Yecla Furniture Fair (FMY), which was set up by a group of small local entrepreneurs in 1961, is the oldest of its kind in Spain. Yecla furniture is protected as products by a "brand of guaranteed label", from the Spanish Chamber of Crafts, certifying quality, components, origin, and techniques. This region has a highly developed tradition of wooden carpentry and carving. CETEM (Technical Research Centre of Furniture and Wood) and its curriculum of industrial and craft training includes the techniques of creating sculptures from old pieces of wood. The centre works closely with a diverse array of companies, with a particular focus on small and medium-sized enterprises (SMEs), spanning various industrial sectors. Collaborations centre around applied research and technology development. CETEM's primary objective is to foster research and development (R&D), innovation, and the transfer of technology within regional and national industries. This initiative aims to enhance competitiveness while playing an active role in socio-economic advancement. The centre's R&D efforts are concentrated in several key areas, including Materials, Adhesion & Polymers; Electronics & Home Automation; Product Engineering; and Industrial Technology & Robotics. Institutional instances such as the Chamber of Crafts of Murcia Region collaborate with CETEM to ensure the protection of wood creations.

The initial visit to Yecla in February 2024 provided valuable perspectives into the interplay between wood craftsmanship and the longstanding industrial heritage of furniture production prevalent in the region. The interview with the practitioner about his professional career and his extensive experience in wood carving provided us with many keys to understanding his activity. The first part of the interview took place at CETEM's premises, while the second part took place in the craftsman's workshop. During the interview, he recounted his very early beginnings as a woodcarver, his apprenticeship process, the influence of his teacher and mentor, and his own experience as a woodcarving trainer as part of professional training courses organised by the local council. These training courses were not continued, and the craftsman assures us that none of his former students took up woodcarving after this training. During the interview, the craftsman evokes the lack of an organised educational system for learning these techniques and, consequently, the rupture in the system of transmission of woodcarving know-how. A large part of his professional practice has focused on the field of furniture but, throughout his career as a woodcarver and following in the footsteps of his master and mentor, part of his practice is closely linked to the production of religious works. Some of them are exhibited in two of the town's museums, the Museum of the Festivities of the Virgin Mary (*Museo Mariano Vírgen del Castillo*) and the Easter Museum (*Museo Semana Santa*).

The part of the interview conducted in his workspace afforded an opportunity to delve deeper into the technical aspects of his professional expertise. Located on an industrial estate, the practitioner's workshop is situated in a large building and comprises several work areas. Standing at his workbench, surrounded by his collection of woodcarving tools –essentially a wide array of gouges in different sizes and shapes– and finished and in-progress parts, the practitioner carries out a series of demonstrations. This phase also enabled the selection of gestures to be recorded in accordance with the structure of the protocol. The selection of woodcarving gestures was based on a series of traditional motifs closely linked to the effects of the use of specific tools during the execution of technical gestures: acanthus leaf (without hollowing), half-round leaf (with hollowing), spiral, volute (a kind of spiral in relief), ball and bead (*bordón*). The recordings of this corpus of technical actions and their associated gestures selected by the artisan according to their relevance, which will be carried out later, will be the basis of the video-elicitation sessions that will take place at a subsequent stage.

With wood as the socio-economic engine of the area, this representative craft instance allows us to examine the dynamic and changing relationship between traditional craft practices and the context of coexisting industrial activities. Moreover, the unique context of this region will enable us to explore the continuities and discontinuities of cultural and symbolic aspects, through the production of both functional objects and religious works.

https://cetem.es/en/

3.4. Limoges porcelain

Figure 7. Limoges Porcelain, January 2024 (image: Arnaud Dubois).

Limoges is a UNESCO Creative City of Crafts and Folk Art, recognized as the French capital of ceramics art. The discovery of kaolin in the 18th century close to the city established its renown in the porcelain craft. The sector accounts for around 60% of the national income with almost 1200 individuals working in the Limoges porcelain craft through workshops, associations, factories, research and development centres, schools, and museums. Since 1881, the Limoges National School of Art and Design (ENSAD-Limoges) trained artists and designers in the porcelain craft. Therefore, the school's initial purpose was to bring an aesthetic dimension to porcelain craft and the school was originally located on the same site as the Limoges National Porcelain Museum. As such, the porcelain workshop of the school is organised like a factory: design of models, plaster turning, making of moulds, casting, stamping, and finally glazing. Projects from students, teachers, artists and designers in residence, and various external requests are developed there. Due to this historical interplay between the technical and aesthetic dimensions of the porcelain craft in Limoges, the focus will be on contemporary practices of porcelain in art and design, and how the technical aspects of this craftsmanship are approached in artistic practice (D6.2).

The recording sessions were held in late January and early February 2024. A prior meeting with the head of the porcelain workshop and the pedagogical technician —a young practitioner and ancient student from the school —both of whom work at the Limoges school, made it possible to decide on the corpus of

gestures to be documented. Thus, the shaping gestures have emerged as the ones we should concentrate on modelling, casting, packing, and deburring. It was also suggested to include a second, more experienced person: a former teacher at the school with an extended career working for different manufactures. This will make it possible to include a comparative dimension concerning the same technical actions and to document different degrees of gestural expertise. Organised and implemented by members of CNAM and ARMINES, the series of recordings took place in different locations in the ENSAD - Limoges porcelain workshop.

The inherent flexibility of the ethnographic protocol for documenting technical gestures makes it possible to adapt and adjust it to the specific temporality of porcelain crafting, punctuated by pauses aligned with the distinct drying phases. Following the sequence of activities outlined by the protocol, after a comprehensive guided tour of the different areas of the workshop, the life course interviews were conducted with the two practitioners. Consistent with the methodological framework, the interviews delved into various aspects of the practitioners' professional trajectories, encompassing their training, pivotal life events shaping their career paths, decision-making junctures, bifurcations, transitions, critical episodes, professional accomplishments, and an array of diverse experiences contributing to the narrative fabric of their professional journeys. The exchanges revolved significantly around the topic of transmission. These interviews proved insightful, allowing addressing issues related to socio-professional status, sources of frustration, moments of satisfaction, as well as distinct perspectives and assertions concerning their vocation. During these interviews, and drawing from the practitioners' professional narratives, elements associated with technical expertise, know-how and technical gestures were explicitly evoked.

While the implementation of the protocol primarily focused on a specific set of technical actions, complementary gestures were captured through traditional observational methods. To ensure a comprehensive analysis across varying levels of experience, expertise, and dexterity, the performance of each technical action was enacted by both practitioners. Documenting the same technical actions performed by two different individuals yields valuable insights into the precision, effectiveness, smoothness, and pace of gestures. Additionally, it sheds light on diverse body postures and their gradual adjustments throughout the technical process, the handling of tools, and the engagement with materials. This approach enables us to gather specific data essential for examining the degree of gestural variability. The video elicitation sessions were conducted with the active participation of both practitioners who watched the material captured through the egocentric camera. Through a series of questions, the practitioners were guided in the process of discovering, from a new perspective, their way of working and helping to make explicit the intentionality of each technical gesture. Given that the two practitioners had different levels of experience and skill, these sessions became an opportunity to correct, improve and deepen the understanding of certain actions as an amplification of the knowledge transmission that usually takes place in the workshop. In order to explore this aspect further, an additional session focusing on the chain of intergenerational transmission of porcelain techniques will be held at a later date.

https://www.ensad-limoges.fr

https://www.unesco.org/en/creative-cities/limoges

3.5. Tinos marble-carving

Figure 8. Tinos Marble Carving, October 2023 (image: Danae Kaplanidi).

Inscribed on the Representative List of Intangible Cultural Heritage in 2015, Tinian Marble Craftsmanship is an expression of the cultural identity of Tinos. Around the village of Pyrgos, there are several marble quarries, a museum dedicated to the history of marble carving techniques (the Museum of Marble Crafts), and a school of fine arts specialised in marble sculpture (Preparatory and Professional School of Fine Arts of Panormos).

PIOP established contact with an experienced marble carver who had collaborated with them in a previous national research program. The carver generously agreed to contribute voluntarily to a project. An initial meeting was scheduled to prepare the recordings and to familiarize the practitioner with the aims, approach, and methods of the project. Following the introductions provided in this meeting, the marble carver was able to start sharing insights into their expertise and experiences.

On-site ethnography, involving observation, note-taking, video, and photo documentation, as well as video elicitation, took place at the end of October 2023. Fieldwork was intensive, despite its limited duration. The practitioners showed the workplace, both inside and outside the workshop area, as well as the organisation of the objects, tools, and materials it contained. A pre-recording interview was conducted following a semi-structured format, with a set of open-ended questions organised into thematic sections

aligning with the guidelines from the Craeft Protocol, as well as insights from [138] and [139]. This interview adhered to ethical standards, with recorded proceedings initiated only after securing participants' consent and encompassed their participants, capturing their responses, insights, and perspectives throughout an engaging conversation. During the discussion on marble carving techniques, it was decided which gestures would be recorded during the fieldwork in Tinos. After the exhortation of the technological partners to find out which are the "primitive" gestures of marble carving, practitioners described that the primary techniques of marking and carving are the most important and the first ones a trained person should master. While crafting, they interrelate and are worked in succession based on the requirements of the task.

Based on the technological requirements of the recording sessions, the participants proposed recording the creation of a carved marble floor tile featuring a traditional sailing boat, a design chosen spontaneously and aligned with their production plan. Such designs are widely known among Tinos marble carvers. Practitioners noted that a specific marble carver's work is recognizable not solely by the design but by the object itself. Furthermore, they suggested recording the traditional method of splitting a marble piece to better understand the role the sound plays during marble carving, and thus the importance of hearing while working.

During the recording session, there was a conscious effort on the part of the practitioner to provide explanations, as it was assumed that observers might not be familiar with the task. Although encouraged to proceed as usual, the practitioner being recorded wanted to share his views. More in-depth questions were reserved for a later video elicitation interview. The recordings captured a variety of tasks, including the carving of a marble floor tile with a traditional motif, the splitting of a cube and the refinement of a semi-finished three-dimensional statue. Insights on the body posture and movement through observation were made and were discussed during the video elicitation interview. The video elicitation interview made use of egocentric video recordings. The interview session was unstructured and articulated around general themes. Throughout the interview, there were occasional pauses, some related to reviewing or forwarding the video. It was observed that a specific type of pause, associated with finding the next gesture, interrupted the conversational flow. Although the discussion was productive, it was suggested that an edited video incorporating both egocentric and side views of each gesture could enhance clarity, particularly when addressing topics such as body posture and movement. Explaining these aspects without visual aids took more time for understanding. The inclusion of visual content might facilitate better comprehension and self-observation.

https://www.piop.gr/en/diktuo-mouseiwn/Mouseio-Marmarotexnias-Tinou/to-mouseio.aspx#

https://ich.unesco.org/en/RL/tinian-marble-craftsmanship-01103

3.6. Ioannina Silversmithing

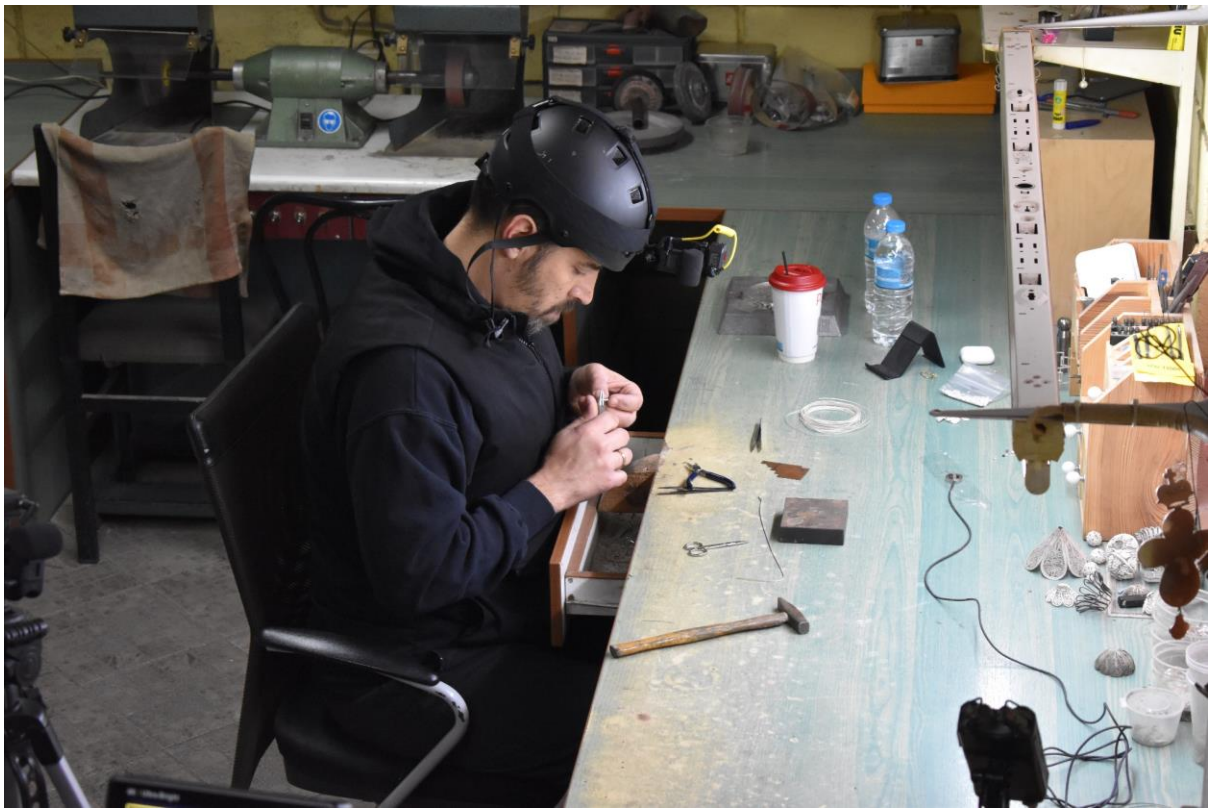

Figure 9. Epirus Silversmithing, December 2023 (image: Danae Kaplanidi).

Silversmithing is inextricably linked to the Craft Heritage of Ioannina, since the 13th century. These crafts developed, flourished, and gave rise to interaction with other centres in the Balkans and the West. Products are jewellery, silverware, and in the past, armoury and armature. The city of Ioannina, situated in the Epirus region, hosts a PIOP network museum dedicated to silversmithing. This museum delves into the history of the craft, the role of silver as a material, the evolution of techniques, and the works of artisans. Ioannina is also home to the Ioannina Traditional Crafts Centre (KEPAVI), a training centre that played a pivotal role in our fieldwork preparations.

The first discussions of the consortium with this institution focused on the selection of possible techniques to observe. It was then suggested to work on sand casting, which is no longer practised today except in the context of historical demonstrations. Filigree, another endangered technique with few remaining practitioners, was also proposed.

Considering the age of the artisans and the contextual needs, it was decided that all tasks, including pre-interviews, would be conducted on-site. The fieldwork took place in December 2023 and encompassed life course interviews and photo documentation. Consortium members were able to visit the workshop of a skilled artisan specialising in filigree, a technique that only this person continues to practice. It was then decided to simultaneously record and conduct an interview during their work. As the artisan practised his craft, he gave explanations, and the team took the opportunity to ask some questions about

tools and techniques. Following the recording, a life course interview was conducted. Additionally, a demonstration of the sand-casting technique was recorded at KEPAVI as part of a school visit.

https://www.kepavi.gr/el/home

3.7. Cretan pottery

Figure 10. Traditional Cretan pottery (images: Giorgis Dalamvelas).

If the practice of Cretan pottery spans millennia, serving as a vital tool for dating Minoan civilization and understanding its extensive trade networks, today, we notice a resurgence of interest in traditional Cretan pottery, blending ancient methods with contemporary designs. Keramion, a workshop situated in Margarites, Rethymnon, serves as a prime example of this revival. Founded by ceramists passionate about preserving and teaching the unique aspects of Margarites Pottery, this workshop utilizes local clays and traditional wood-burning kilns to make pottery while also embracing modern artistic sensibilities.

The visit was undertaken to delve into the intricate processes involved in crafting traditional Cretan pottery. This immersive exploration began with an introduction to the historical origins of ceramics, followed by engaging with local artisans to learn ancient techniques passed down through generations. The journey of Cretan pottery starts in the mountainous terrains where raw materials like schist and earth are meticulously extracted. These natural resources are then transformed into clay at open-air workshops, laying the groundwork for the pottery-making process. The study further analyzed the stages involved in crafting ancient ceramic vessels, including detailed presentations by local potters on construction techniques and the diverse forms and functionalities of ceramic pitchers. A distinctive feature of Cretan ceramics is the traditional decoration using sheep's wool brushes and the polishing of ceramics with pebbles, which highlights the aesthetic considerations and cultural essence of the region.

The examination of different types of wood-firing kilns holds a central interest in understanding the nuances of Cretan pottery production. Firstly, the choice of kiln design reflects the intersection between tradition and modernity in pottery-making practices. The juxtaposition of a modern, box-shaped kiln with a traditional, open, circular updraft kiln signifies the evolution of techniques over time. By studying both types of kilns, we can trace the historical trajectory of pottery firing methods, from ancient practices to contemporary adaptations. Moreover, the firing process itself is a critical aspect of pottery production, influencing the final aesthetic and structural qualities of the ceramics. The unique colourations and strength acquired during firing contribute significantly to the artistic value and durability of Cretan

pottery. Understanding the intricacies of this process sheds light on the craftsmanship involved and allows for a deeper appreciation of the skill and expertise of ancient Cretan potters. Furthermore, the reduction phase, aimed at removing oxygen from the kiln, adds another layer of complexity to the firing process. This phase is essential for achieving specific effects, such as variations in colour and surface texture, which are characteristic of Cretan pottery. By examining how different kiln designs facilitate the reduction phase, we gain insights into the technical aspects of pottery firing and its impact on the final product.

https://keramion.gr/

3.8. Cretan textiles

Figure 11. Traditional Cretan textile manufacturing (image: Mingei IA).

Cretan woven fabrics, known for their complex geometric patterns primarily featuring the diamond shape, represent a significant part of the island's textile heritage. These patterns, introduced in the 11th Century have been passed down through generations, becoming a staple of Cretan folk art and tradition. Initiatives led by organizations like the Development Association of Women Entrepreneurs of Crete (DAWEC) have played a crucial role in preserving and revitalizing these ancient weaving traditions.

Founded in 2002 in Heraklion, DAWEC is a non-profit organization that supports and promotes women's entrepreneurship in Crete by providing business training, mentoring, networking opportunities, and access to funding. It also advocates for gender equality and women's empowerment in the business world. One of its initiatives in this area is the "Weaving Crete" project, which aims to revive the art of weaving in Crete and to create new opportunities for women weavers. The project involves training women in traditional weaving techniques and helping them develop new designs and products that incorporate these techniques.

The weaving technique, particularly the "xobliasta" or "embroidery on the loom", made with wool and cotton, was our subject of interest because it allows for intricate patterns to be woven directly into the fabric, creating textiles that are both functional and culturally significant. This weaving technique is complicated, time-consuming and requires great care and attention. To create the decorative motifs, the weaver passes the coloured weft, wound into small skeins, through the warps by hand. As different coloured wefts alternate in each row, the weaver must judge the length of each colour line carefully, counting the number of warp threads. Photographic material was collected on many textiles, illustrating the different textile motifs and their correspondence to the regions that use such motifs. Furthermore,

interviews on the contemporary uses of textiles and the business opportunities for modern weavers and textile makers have been conducted. These interviews have highlighted the challenges faced by modern weavers, including the labour-intensive nature of traditional techniques and competition from mass-produced textiles. However, they also underscore the resilience and innovation within the industry, with artisans adapting traditional methods to create a diverse range of products suited to modern lifestyles.

https://www.facebook.com/cretanbusinesswomen/

https://womencrete.gr/

4. Data Collection Management and Analysis

Literature sources regarding crafts are available in a plethora of online and offline resources. Encyclopaedias provide generic context but also references to sources and literature. An encyclopaedic background establishes a preliminary orientation, including vocabulary entries. Further research provides documentation, bibliographic assets, and online resources on prior ethnographic works on the same or similar crafts, as well as literature containing instructions on similar manufacturing actions. More specific sources stem from curated material. These can be museum guides, catalogues, magazines, essays, and student theses. Photographs and illustrations in literature or photographic collections, as well as documentaries and ethnographic films.

Besides the technical practice of a craft, it is important to review the social and historical contexts of a craft instance. This can provide an understanding of the specific materials used, the motifs used to decorate artefacts, and the traditions related to the craft instance.

The relevant topics encompass various dimensions of the craft, including the contextualization of the craft within its technological evolution and the socio-economic history of the communities involved in its practice. This involves delving into specific historical figures, communities, locations, and artefacts associated with the craft. Additionally, exploring a timeline of craft history becomes imperative, shedding light on its origins, technical advancements, and aesthetic evolution within the realms of art and design history. Historical significance is unearthed through an examination of figures, events, and objects that have played pivotal roles in shaping the expression of the craft within local communities.

Furthermore, a compilation of stories and historical artefacts serves as a valuable resource, providing insights that both illustrate and contextualise the evolution of the craft over time. This narrative approach offers a nuanced understanding of how the craft has been shaped by cultural, social, and artistic influences.

Moreover, an exploration of the craft's relationship with sustainability and natural resources emerges as a critical aspect. Understanding how the craft interacts with and impacts the environment, as well as its reliance on natural resources, contributes to a comprehensive perspective. This angle ensures that the craft's practices align with sustainable principles, addressing the contemporary emphasis on responsible resource usage. In essence, these diverse topics collectively form a rich tapestry of knowledge, allowing for a holistic exploration of the craft, its historical roots, and its intricate connections with society, art, and the environment.

4.1. Data types

During the ethnographic recording process, a diverse array of digital files is harnessed to encapsulate various facets of the research endeavour and participants' experiences. These digital file types, utilised for documenting the unfolding crafting activities, encompass a comprehensive range of mediums.

Audio recordings serve as a capturing mechanism for spoken interactions, conversations, and ambient sounds within the crafting session. This auditory archive not only immerses the researcher in the environmental nuances but also facilitates an in-depth analysis, especially when interviews are conducted.

The recordings of these interviews become essential components, providing a written record of spoken content that contributes to the analytical depth of the study.

In tandem, video recordings emerge as powerful tools for capturing visual information, including body language, facial expressions, and non-verbal cues. This visual medium is particularly valuable for comprehending the scene and delving into the intricacies of social interactions and behaviours within the natural context of the crafting session. Video recordings of interviews, if conducted, stand as indispensable resources for subsequent analysis, offering a visual dimension to the spoken narratives.

Adding another layer to the recording repertoire, motion capture recordings step into the forefront. These recordings meticulously trace the 3D trajectories of human movements, providing invaluable insights into the intricate dance of gestures and motions during craft actions. This medium becomes particularly instrumental in deciphering the nuances of human motion within the crafting process.

Photographs, as a visual medium, serve to capture intricate details of the environment, artefacts, settings, and the participants themselves. Beyond mere visual documentation, photographs play a crucial role in contributing to the broader ethnographic narrative, offering a tangible visual understanding of the contextual elements at play.

Complementing these visual and auditory dimensions, spatial information is seamlessly integrated into the research process. Ethnographers, recognizing the relevance of spatial context, may opt to create maps or sketches of the physical environment. These illustrations serve to vividly portray the locations and spatial relationships within the workspace, enriching the overall understanding of the crafting dynamics.

This multifaceted approach to recording employs a symphony of audio, visual, motion, and spatial elements, creating a rich and nuanced tapestry of data that encapsulates the essence of the crafting experience.

4.2. File management

Effectively organising digital recordings from an ethnographic session is pivotal, ensuring seamless access, streamlined analysis, and meticulous documentation of your research. Here is a comprehensive guide to navigating the organisational process:

Commence by establishing a central folder for your ethnographic project, endowing it with a clear and descriptive name that encapsulates its essence. This main folder serves as the hub for all your project-related materials. Within this overarching folder, institute subfolders bearing the names of the dates and locations for each ethnographic session. This strategic organisation facilitates swift navigation, allowing you to locate recordings promptly based on the specific context of each session.

Given the diverse media types involved in your sessions, including audio, video, photos, and documents, institute further subfolders within each session folder, categorically arranged for each type of media. These sub-folders typically encompass designated spaces for "Audio," "Video," "Photographs," "MoCap" (Motion Capture), and "Documents."

To maintain a sense of consistency and clarity, employ a standardised file naming convention. While the specifics may be tailored to your ethnographic team's preferences, it is advisable to incorporate key

details such as session dates, participant names or IDs, and perhaps a succinct content description. This practice expedites the identification of the recording's content without necessitating its immediate opening.

Parallelly, establish a spreadsheet that compiles a comprehensive list of participants' names, IDs, and any pseudonyms used during the sessions. This document, positioned in the main folder, serves as a quick reference point, facilitating efficient cross-referencing.

In addition to media recordings, maintain a separate folder specifically dedicated to session notes, fieldwork diaries, and any pertinent logs generated throughout the ethnographic sessions. These contextual notes play a pivotal role in providing nuanced background information to accompany the recordings, significantly easing the subsequent analysis process.

By adhering to this methodical approach, you create a structured and accessible repository for your ethnographic materials, fostering a conducive environment for rigorous analysis and meaningful documentation of your research endeavours.

4.3. Visual annotations

Annotation of endurant digital assets regards the annotation of images and 3D models. By annotating the visual material, we identify objects and symbols in images and video, which can later inform their analysis and understanding. Visual annotations enhance the understanding, analysis, and communication of visual materials, such as photographs, sketches, and artefacts.

A wide range of image annotation editors exist, e.g. [140, 141, 142, 143, 144]. All of them offer annotations upon the overall file at point locations in images. Standard features are the annotation of arbitrary (freehand) image regions and rectangular bounding boxes within the image.

The case is similar for 3D model annotators, e.g. [145, 146, 147, 148, 149, 150]. Point location annotations on the surface of the 3D model are offered by all editors. In objects, the user may wish to indicate which piece of a carafe is the handle or indicate a motif or symbol upon a piece of pottery. The annotation of free-hand regions on the 3D model is a feature that is not found in all editors. The reason is the somewhat tedious user task of marking the region of interest. We recommend using an annotation editor that enables the specification of geodesic regions of interest upon 3D models, a feature not available in most editors that offer only point-based annotation, to facilitate region annotations.

4.4. Event parsing

Crafting actions are part of the production process and may be specific to a technique or the use of a tool. Video and MoCap recordings or the crafting process are used to demonstrate crafting actions. However, in this way, no measurement of motion can serve documentation purposes and accurate reenactment of the recorded actions.

We call event parsing the task of separating parts of a motion recording that correspond to individual craft actions into individual motion animation clips. Parsing is key in the comprehension of human activities because it enables the association of movements with entries in gesture and action vocabularies. By

articulating motion into actions, a more insightful understanding of crafting activities is achieved because individual gestures can be isolated, studied, and practised. Moreover, using these clips as references crafting processes can be understood as action sequences, rather than continuous streams of human movements.

In this context, training datasets have been developed [151, 152] that offer recordings of individual gestures, where an actor performs the gestures in the environment of a motion capture laboratory. The segmentation of the examples is provided “by construction” as training examples contain a gesture in each one.

Ethnographic recordings are pre-processed for synchronisation and the AnimIO software [153] is used to create motion segments. AnimIO is thus used to annotate motion data per the action performed. That is AnimIO is used to temporally delimit motion recordings into segments.

In this way, animation libraries are created, which are collections of animation files. Animation files are motion segments, containing the recording of individual actions by one or multiple recording modalities. The motion data are encoded in a human skeletal model configuration. This is achieved either directly from the MoCap recording or through the analysis of video recordings.

4.5. Event logging

Event logging is used to systematically record and document events, activities, interactions, and observations. It involves keeping a detailed chronological record of events as they unfold during fieldwork.

Event logs are verbal annotations that describe the contents of an ethnographic video, temporally corresponding to segments of said video [5]. Event logs promote immediate reflection and a summary of actions that both assist in later assessment and comprehension. The content of these logs summarises the activities taking place in the corresponding video segment. An added-value benefit is that when terminology is followed event logs can be used as searchable digital records [154], using keyword search.

These short-term observations provide a narrative of the proceedings but not a complete record. The purpose is to counter the decay of human memory because details are already forgotten when the video is later reviewed. The utility of event logs is to obtain an immediate review of the session to facilitate the subsequent review of the material. We recommend the authoring of event logs either during observation or as soon as possible after it.

To reduce the time interval between observations and authoring, this work puts forward advances in speech-to-text transcription, so that ethnographers can simultaneously commentate while recording. As speaking is faster than typing, this technology enables rapid note-taking to reduce the effect of human memory decay. Because speech-to-text technology eliminates the need for typing or writing, it enables hands-free operation. This is useful as the ethnographer can comment while recording. Although modern speech-to-text systems have significantly improved their accuracy rates they are not infallible, a review of the transcribed text is required. As speech-to-text tools integrate seamlessly with word-processing applications the review can take place at the software of choice.

The content of these logs is observations of practitioners at work, including techniques, materials used, interactions with others, and the ambience of the work environment. Craft ethnography often focuses on

the craft-making process itself. Event logging allows researchers to document each step of the process, from selecting materials to executing techniques and creating the final artefact.

Alongside the recorded events, researchers often include their reflections, impressions, and insights related to the events. This adds a layer of interpretation and analysis to the raw data. The detailed records generated through event logging become valuable data for analysis. Researchers can identify patterns, trends, and themes by reviewing the logged events retrospectively.

Event logs must be reviewed with the participating practitioners. Event logs can serve as a form of verification and validation. When sharing findings with participants, the logs can help ensure accuracy and shared understanding. As such, event logging provides a comprehensive record that can be referred to when conducting in-depth analyses, creating reports, or presenting research findings. If possible, the involvement of additional practitioners and community members in the review is important to capture multiple perspectives and insights.

To effectively use event logging in craft ethnography a structured template for event logging is designed that includes fields for date, time, description of the event, participants involved, location, and any additional relevant details. When completing the template it is important to maintain consistency in recording events, ensuring that important details are not overlooked.

5. Conclusions

In conclusion, the Craeft Ethnographic Protocol serves as a conduit, fostering a meaningful dialogue between the pragmatic realm of ethnographic research and the formalistic domain of artificial intelligence. This symbiotic relationship not only cultivates a unique synergy but also propels both social sciences and computer sciences into a realm of self-reflection, compelling them to scrutinise and evaluate their theoretical and methodological foundations in the context of understanding and representing crafts practices.

At its core, pragmatism within the protocol signifies a hands-on, experiential approach rooted in the real-world context of craft-making processes. Ethnographic research, with its pragmatic underpinnings, brings forth an immersive exploration of the social and cultural dimensions surrounding crafts, capturing artisanal practices in their natural settings. On the flip side, the formalism embedded in the protocol, driven by artificial intelligence, imparts a structured and systematic framework to the wealth of data accrued through ethnographic endeavours. It introduces computational methodologies, analytical tools, and modelling techniques that formalise the intricate web of craft-related information into organised, comprehensible structures. This formalist lens serves as a powerful analytical engine, allowing for the extraction of patterns, correlations, and insights that might elude traditional ethnographic approaches.

The conjunction of pragmatism and formalism within the protocol is not a mere juxtaposition; rather, it is a cohesive integration that leverages the strengths of both approaches. The pragmatic facet ensures that the protocol remains grounded in the lived experiences of artisans, capturing the tactile, sensory, and cultural dimensions of craft practices. Simultaneously, the formalistic dimension introduces precision and scalability that transcends the limitations of subjective interpretation, providing a systematic way to process and analyse the vast array of ethnographic data. This synergy prompts a transformative dialogue between the inherently flexible, context-driven nature of ethnographic research and the structured, algorithmic realm of artificial intelligence. The protocol becomes a meeting ground where the depth of ethnographic insights and the computational prowess of artificial intelligence converge.

As a result, it prompts a revaluation of how craft understanding and representation are approached, pushing boundaries, and sparking innovation. It is a transformative interplay that brings forth a holistic and enriched comprehension of craft practices and becomes a catalyst for the generation of truly innovative knowledge surrounding crafts. The protocol acts as a crucible, forcing a convergence of perspectives that transcends traditional boundaries. This convergence not only illuminates the multifaceted nature of crafts but also challenges pre-existing assumptions, sparking a renaissance in how we conceptualise, study, and represent these intricate practices.

Beyond its theoretical underpinnings, the Craeft Ethnographic Protocol manifests its practical impact by extending its influence into institutions dedicated to the transmission of material knowledge. This outreach permeates the very fabric of pedagogical landscapes, touching upon vocational schools, fine arts and design institutions, and museums. Within these realms, the protocol emerges as a potent pedagogical force, wielding the potential to reconfigure the transmission of skills, especially in the context of ICH.

At the heart of this application lies the recognition that craft practices are not static entities; they are dynamic traditions deeply rooted in the expertise and tacit knowledge of skilled artisans. The protocol encapsulates the intricacies of these practices, preserving the nuances that might be overlooked in

traditional educational approaches. As such, its integration into vocational schools becomes a catalyst for a more profound and experiential learning experience. In schools of fine arts and design, where the intersection of creativity and craftsmanship is paramount, the Craeft protocol offers a novel approach to skill enhancement. It not only imparts technical proficiency but also nurtures an understanding of the cultural, historical, and contextual dimensions of crafts. The protocol, with its interdisciplinary nature, becomes a conduit for aspiring artisans to delve into the rich tapestry of cultural heritage embedded in their craft, fostering a holistic approach to skill acquisition. Museums, as repositories of cultural knowledge, play a crucial role in the transmission of skills and traditions. The application of the Craeft protocol within these institutions amplifies their educational mandate. By utilising the data collected for craft representation, museums become dynamic spaces for interactive learning, where visitors can engage with crafts not merely as artefacts but as living traditions. The protocol, with its digital re-enactment capabilities, breathes life into the static exhibits, offering a dynamic and immersive educational experience.

In the context of ICH, the concept of skill transmission is inherently intertwined with the safeguarding of cultural practices. The Craeft protocol, by encapsulating the subtleties of craft practices, ensures that the transmission of skills goes beyond the technical aspects to include the cultural nuances, oral traditions, and community dynamics inherent in ICH. This holistic approach aligns with the UNESCO framework for safeguarding intangible heritage, which emphasises the importance of transmission in its broader cultural context, making sure traditions stay alive for the next generations.

In the broader scientific landscape, this conclusion resonates deeply with the core tenets of ethnography. Ethnographic research, as exemplified in the Craeft project, is not just an observational exercise; it is an epistemic journey that unveils the layers of cultural practices and the embodiment of knowledge within them. The protocol's emphasis on participant observation, engagement, and the collection of diverse data modalities speaks to the core of ethnographic inquiry – a holistic exploration of both the tangible and intangible aspects of crafts. By breaking away from the dichotomy between theory and practice, it recognizes that the essence of cultural practices is not confined to textbooks or theoretical frameworks alone. Instead, it resides in the lived experiences, the tacit knowledge of artisans, and the dynamic interplay between tradition and adaptation. This approach to skill transmission emphasises learning by doing, experiential knowledge, and the preservation of craft traditions through hands-on engagement.

Glossary

A vocabulary is created for all steps of the proposed methodology so that outcomes are meaningful and explanatory across disciplines. The required quality of this vocabulary is to be interdisciplinary, that is to be comprehensible to all members of the craft understanding team. This vocabulary will be extended during the project as terms that require definition and explanation across disciplines are identified.

We stress that the terms below are to be considered in the context of traditional crafts. Not all of the terms are used in this deliverable; the vocabulary below consists of a reference for the entire Craeft project. In some cases, we deviate from the format of a dictionary and provide a brief discussion of terms to better convey the notion we intend.

It is furthermore noted that this vocabulary serves the goal of research communication. Individual vocabularies for the craft instances studied are provided in D.1.2. Knowledge collection and representation.

The terms below are thematically organised in sub-sections:

Knowledge representation

The **entities** involved in a crafting process are either endurants or perdurants, corresponding to “continuants” and “occurrents” [8] in Basic Formal Ontology, respectively.

An **endurant** is an entity that persists, maintains its identity, and remains wholly present at any given time during its existence, even as it may undergo various kinds of changes. Endurants are materials, tools, machines, workplaces, and craft products.

Perdurants refer to entities that unfold or occur over time, representing events, processes, or any changes that happen. Perdurants are events, actions, processes, natural phenomena, or changes that happen to or within endurants. Perdurants are characterized by their temporal parts or phases; they have different parts at different times, representing the various stages or aspects of the process or event.

A **tool** is an object or body member employed to make use of an affordance it bears [10] e.g., scissors provide the affordance of cutting.

A **machine** is an apparatus composed of Archimedean Simple Machines.

An **action** is an event that consists of doing something intentionally by some agent of action. Crafting actions refer to the transformation of materials into intermediate or final craft products.

An **activity** is a set of actions carried out by one or more persons. Thus, activities are events.

A **crafting process**, or simply **process**, is a set of activities that transform materials into articles of craft.

A **workflow** is an orchestrated and repeatable activity, enabled by the organisation of resources into processes.

A **crafting process schema**, or simply **process schema**, is a representative prescription for how a set of activities should operate in a workflow to regularly achieve desired outcomes [155].

To refer to parts of a process, we say that processes are composed of **process steps**, or simply **steps**, independently of their depth in the process.

To refer to parts of a process schema we say that process schemas are step **process schemas**, or simply **step schemas**, independently of their depth in the process schema.

Craft dimensions. In the literature, CH is often distinguished between tangible and intangible. Though crafts are considered intangible heritage, the way that this heritage is manifested is through material transformations and into articles of craft. Artefacts, tools, and sites belong to the tangible domain. The intangible domain includes history, collective memories, values, aesthetics and crafting instructions and processes. Intangible heritage is regarded as an intellectual process that is performed by living humans.

We refer to the workspace where the craft is exercised as the **scene**. **Scene elements** are the objects in the scene. **Scene properties** are the environmental properties, such as temperature.

Physics

Mechanical advantage is a measure of the force amplification achieved by using a tool, mechanical device, or machine system [156]. The device trades off input forces against movement to obtain a desired amplification in the output force. The model for this is the law of the lever.

Physical or chemical properties of materials are categorized as intensive or extensive, according to how the property changes when the size or extent of the material changes. An **intensive property** or intensive quantity is one whose magnitude is independent of the size of the system, such as density. An **extensive property** is one whose magnitude is additive, such as mass. A **material property** is an intensive property of a material.

Craft knowledge

Physical assets are the objects (endurants) and events (perdurants) that are involved in a craft.

Folk Art is art produced from an indigenous culture or by peasants or other labouring tradespeople.

Patronage is the support, encouragement, privilege, or financial aid that an organisation or individual bestows on another, particularly in the arts.

Apprenticeship is a system or practice of training a new generation of practitioners of a trade or profession.

Compagnonnage is a traditional mentoring network through which to learn a trade while developing character by experiencing community life and travelling [UNESCO inscription 5.COM 6.12].

Work of certainty refers to predetermined actions outside the control of the operative. **Tools of certainty** are moulds, hand presses, looms, stabilising jigs, measures, etc. **Work of risk** regards actions that depend on practitioner care, judgement, and dexterity. **Tools of risk** are scissors, knitting needles, chisels, paint brushes etc [157]. Risk and certainty are thought of as the two ends of a "sliding scale", rather than a strict dichotomy.

An **artisan** or a **practitioner** is a skilled craft worker who makes or creates material goods by hand.

A **technique** is a way of carrying out a particular task, such as the execution or performance of an artistic work or a scientific procedure.

Traditional knowledge refers to know-how, skills, and practices that are developed, sustained, and passed on from generation to generation within a community.

Iconography refers to the visual images and symbols used in a work of art or the study or interpretation of these.

Digital representation

Craft Representation or **Craft Digitisation** is a digital representation of a craft instance and includes digital representations of knowledge elements and digital assets. Knowledge elements regard objects, materials, tools, locations, persons, actions, processes, and contextual knowledge in the form of events.

Digital assets are computer files containing the digital recordings of physical assets.

An **activity diagram** is a flowchart that models workflows.

A **skeletal tree** is a hierarchical data structure that represents avatar joints and limbs and is rooted at the avatar's torso. The branches of this tree are called body members. Human motion measurements take into account the anatomy of the human body and are topologically organised in a skeletal tree.

Human factors

A **posture** is the configuration of the skeletal tree or a branch of this tree at a moment in time.

A **gesture** is a chronologically ordered sequence of postures.

The **pose** of a rigid object is its location and orientation in 3D space, or coordinate frame.

Skill is the ability to do something well.

Dexterity is the skill of performing tasks with the hands.

Cognitive sciences

Sensory imagery arises from sensory experiences and encompasses the mental representations that are evoked by all senses and not solely vision. **Repeated practice** and **attention** to the imagery produced during acting are known to foster learning and reduce the risk of "free-hand" operations requiring tacit knowledge (e.g. in music).

Mental imagery refers to the sensory images of the *"mind's eye"* (or finger, ear, etc) [26]. We use the term 'mental imagery' to refer to representations and the accompanying experience of sensory information without a direct external stimulus. Such representations are recalled from memory and lead one to re-experience a version of the original stimulus or some novel combination of stimuli [158].

Material **qualities** or qualia are instances of subjective, conscious experience. Qualia are sensed, e.g. "hand-feel", softness, and smoothness, can be recognised, and can be recalled as mental imagery, such as when thinking about the colour of amber, the feel of satin, or the timbre of the oboe.

Tacit knowledge is a type of knowledge that is difficult to convey to others by writing it down or verbalising it [159, 160, 161].

Appendix A

This section serves as an index of the mechanisms and material properties involved in the RCIs.

A.1 Mechanical characterisation of RCIs

Mechanical characterization typically involves the study and assessment of various mechanical properties and behaviours of materials.

Craeft focuses on modelling crafting processes through four elementary actions. These are Add/Subtract (material addition or removal), Interlock (overlapping or fitting together), and Free-form (mass-preserving shaping of materials). Craeft employs archetypal simulators to delve into craft mechanics. Hands and feet serve as crucial tools and sensors in crafting. The eight RCIs employ distinct mechanical actions. The following matrix offers an overview of how RCIs engage with specific actions, following the aforementioned classification.

Table 1. Mechanical principles per craft instance.

Material/Action	Add/Subtract	Interlock	Free-form
Nancy Glassblowing	X		X
Aubusson Tapestry		X	
Yecla Wood carving	X		X
Limoges Porcelain	X		X
Tinos Marble carving	X		
Ioannina Silversmithing	X		
Cretan Pottery			X
Cretan Textiles		X	

The values reported below are obtained from the MatWeb material property library. Note that the exact values can vary based on the type and composition of glass used in specific applications.

A.1.1 Nancy Glassblowing

In glassblowing, practitioners shape the glass by adding and subtracting material, mechanical characterization involves studying the tensile strength of glass rods used, modelling the thermal expansion of glass during the blowing process, or characterizing the brittleness of glass to prevent breakage during shaping. Glassblowers master the art of transforming molten glass into mesmerizing, flowing shapes. They do this through precise 3D and 2D transformations, creating stunning glassware, sculptures, and artistic installations.

Table 2. Glass.

Density	2.4 g⁄cm3
Young's Modulus	51 to 126 GPa
Poisson's Ratio	0.2 - 0.27
Tensile Strength	7 MPa
Hardness	5.5 - 7 Mohs
Modulus of Elasticity	60-64 GPa
Compression Resistance	800-1000 MPa

A.1.2 Aubusson tapestry

For tapestry, where materials are interlocked, mechanical characterization focuses on the tensile properties of the textile threads, modelling the load-bearing capacity of the interlocking patterns, or characterizing the elasticity of threads to ensure the tapestry's structural integrity. Wool is the primary material used for weaving Aubusson tapestries. It provides warmth, durability, and vibrant colours to the tapestry.

Table 3. Wool.

Density	1.31 g⁄cm3
Tensile Strength	200-600 MPa
Tenacity	0.141 N⁄tex

A.1.3 Yecla woodcarving

In woodcarving, practitioners showcase their mastery by delicately balancing the actions of adding and subtracting material from wood. When adding, they intricately carve patterns and motifs, enhancing the wood's beauty. Conversely, during subtraction, they sculpt and shape wood forms with precision. In woodcarving, which involves shaping wood in a free-form manner, mechanical characterization includes modelling the stress distribution in wood as it's carved, characterizing the wood's hardness for carving tool selection or analysing the impact of moisture content on wood's dimensional stability.

Table 4. Wood.

Density	0.3 - 0.9 g⁄cm3
Tensile Strength	5-50 MPa
Compressive Strength	30-100 MPa

Flexural Strength	50-150 MPa
Modulus of Elasticity	5000-20000 MPa
Thermal Conductivity	0.03-0.12 W/m ∗ K

A.1.4 Limoges porcelain

Porcelain Pottery (Add/Subtract and Free-form): In porcelain pottery, practitioners add and subtract clay. Mechanical characterization involves modelling clay shrinkage during firing, assessing porcelain's compressive strength for stability, and studying glaze thermal expansion for proper pottery fit. Porcelain pottery also includes "Free-form" crafting. Practitioners use mass-preserving, free-form 3D and 2D transformations to create unique pieces, giving free rein to their artistic expression. Clay particles stick together due to electrical forces, making them cohesive and allowing them to maintain their shape when moulded.

Table 5. Porcelain.

Density	2.2 to 2.4 g/cm3
Tensile Strength	1500-2500 MPa
Compressive Strength	25000-50000 MPa
Flexural Strength	3500-6000 MPa
Modulus of Elasticity	7-10 GPa
Hardness	8-8.5 Mohs

A.1.5 Tinos marble-carving

For marble crafts, which involve carving and shaping marble, mechanical characterization includes modelling the hardness and abrasion resistance of different types of marble, characterizing the tensile strength of marble slabs for large sculptures, or studying the fracture toughness of marble to prevent cracks during carving.

Table 6. Marble.

Density	2.5 to 2.8 g/cm3
Tensile Strength	7-20 MPa
Compressive Strength	68.9-241 MPa
Flexural Strength	15-25 MPa
Modulus of Elasticity	60 GPa

Hardness	3 Mohs
Modulus of Rupture	0.00410-0.0276 GPa
Transverse Strength	4-27 MPa
Impact Toughness	0.787-9.06 cm⁄cm2

A.1.6 Ioannina silversmithing

In silversmithing, practitioners work with silver, and mechanical characterization includes understanding how silver can be shaped and its properties like flexibility for jewellery-making. This involves studying how silver wires can be pulled into thin threads and how silver components hold up when bent and formed.

Table 7. Silver.

Density	10.49 g⁄cm3
Tensile Strength	140 MPa
Compressive Strength	45-300 MPa
Poisson's Ratio	0.37-0.39
Shear Modulus	27.8 GPa
Young's Modulus	69-74 GPa
Modulus of Elasticity	76 GPa

A.1.7 Cretan pottery

For clay pottery, which involves shaping clay in a free-form manner, mechanical characterization includes modelling the plasticity and workability of different clay types, characterizing the thermal properties of clay to determine firing temperatures or analysing the porosity of clayware for glaze absorption and water retention.

Table 8. Clay.

Density	2.2 to 2.7 g⁄cm3
Electrical Resistivity	100-1000 Ohm ∗ cm
Specific Heat Capacity	0.837 J⁄g ∗ C
Thermal Conductivity	1.67 W⁄m ∗ K

A.1.8 Cretan Textiles

In traditional textile weaving and knitting, where threads interlock to create fabric, mechanical characterization might focus on modelling the tensile strength of different textile fibres, characterizing the elasticity of textile materials for stretch and recovery properties, or analysing the frictional properties of threads in interlocking patterns. Silk is a natural fibre produced by silkworms and is known for its softness, sheen, and luxurious feel. Cotton threads or fabric may be used as a base or backing material for the tapestry, providing structure and stability. Wool has been mentioned earlier (see above).

Table 9. Silk.

Density	1.34 g⁄cm3
Tensile Strength	500-1000 MPa
Tenacity	0.353 N⁄tex

Table 10. Cotton.

Density	1.52 g⁄cm3
Tensile Strength	210-680 MPa
Tenacity	0.353 N⁄tex

For wool, see Aubusson tapestry above.

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