care, judgment, dexterity

CRAEFT

Toys and games for informal craft education

Project Acronym	Craeft
Project Title	Craft Understanding, Education, Training, and Preservation for Posterity and Prosperity
Project Number	101094349
Deliverable Number	D4.3
Deliverable Title	Toys & games for informal craft education
Work Package	WP4
Authors	Nikolaos Partarakis and Xenophon Zabulis
Number of pages	151

This project has received funding from the European Commission, under the Horizon Europe research and innovation programme, Grant Agreement No 101094349.
http://www.craeft.eu/

Executive summary

Traditional crafts represent a critical yet fragile component of intangible cultural heritage (ICH), as their continuity depends on the transmission of embodied skills, tacit knowledge, and material practices rather than on the preservation of static artefacts. In contemporary societies, this transmission is increasingly disrupted by industrialisation, the decline of apprenticeship systems, and the growing distance between everyday life and manual craft practices. The CRAEFT project addresses this challenge by investigating how toys, games, and playful activities—digital, physical, and hybrid—can function as effective instruments for informal craft education and cultural heritage transmission.

This deliverable (D4.3) examines how game-based approaches can translate complex craft knowledge into accessible, engaging, and experiential learning formats. Games are particularly suited to this role because they can model constraints, tools, risks, and decision-making processes in interactive systems that encourage exploration, experimentation, and reflection. Rather than replacing traditional craft education, the approaches presented here aim to complement it by providing entry points for children, non-specialists, and wider audiences to engage meaningfully with craft practices.

Three broad categories of educational games are explored. **Digital games** include immersive simulators and interactive environments that allow users to practice or explore craft techniques virtually, such as pottery throwing, woodturning, and jewellery making. These games emphasise procedural learning, perceptual awareness, and embodied interaction, while removing barriers related to materials, equipment, or safety. **Physical games and toys**, often enabled through downloadable and 3D-printable designs, provide tangible, hands-on engagement with simplified versions of craft tools and processes. These activities highlight materiality, manual coordination, and creativity, demonstrating that effective craft education can occur with both advanced fabrication technologies and improvised, everyday materials. **Hybrid games and activities** combine digital guidance with physical making, linking virtual tutorials, simulations, or documentation with real-world crafting actions and artefacts.

At the core of the deliverable is CRAEFT's systematic methodological approach to transforming traditional crafts into educational games. This approach begins with an in-depth understanding of craft practices through documentation, ethnography, video elicitation, simulation, and digitisation. The resulting data and knowledge are then simplified and abstracted into game mechanics that preserve essential craft dynamics while remaining accessible to younger audiences. The final step focuses on educational impact, ensuring that games not only teach technical aspects but also communicate cultural significance, historical context, and the values embedded in craftsmanship.

The deliverable documents include multiple case studies that illustrate this approach. These include digital craft simulators and immersive experiences. This open-source board game models artisanal production through strategic play, 3D-printed looms and moulds for hands-on learning, and low-tech educational activities based on improvised tools. Together, these examples demonstrate the versatility of game-based approaches across different technologies, age groups, and learning contexts, including classrooms, museums, workshops, and informal domestic settings.

Overall, this deliverable shows that toys and games can serve as powerful mediators between traditional crafts and contemporary learners. By combining rigorous research, modern digital and

fabrication technologies, and playful interaction, CRAEFT proposes scalable and adaptable methods for safeguarding and revitalising craft heritage. These methods support informal learning, foster curiosity and appreciation, and contribute to the long-term sustainability of traditional crafts as living cultural practices.

Chapter 1 – Introduction. This chapter establishes the motivation and context for the deliverable. It frames traditional crafts as a vulnerable form of cultural heritage and identifies the limitations of conventional preservation strategies. The chapter introduces games as a promising educational medium capable of addressing these challenges, outlines the scope of digital, physical, and hybrid games, and situates the work within broader discussions of gamification and experiential learning for cultural heritage.

Chapter 2 – CRAEFT's Approach. Chapter 2 presents the methodological backbone of the deliverable. It describes a four-step approach: systematic understanding of crafts, generation of knowledge and data, simplification through game design, and assessment of educational impact. The chapter emphasises authenticity, research-driven design, and the careful abstraction of craft practices into playable forms. It also clarifies how advanced technologies such as digitisation, simulation, and 3D printing are used to bridge traditional craftsmanship and contemporary learning environments.

Chapter 3 – Digital Games. This chapter examines digital games as tools for craft education, focusing on both procedural simulation and perceptual exploration. Through detailed case studies—including a hybrid board game, pottery simulators, XR workshops, jewellery immersion experiences, and a woodturning game—it demonstrates how digital environments can model craft processes, tools, risks, and aesthetics. The chapter highlights the educational value of embodied interaction, immersive scale, and interactive documentation, as well as the benefits of open-source and hybrid analogue–digital implementations.

Chapter 4 – Physical Toys and Games. Chapter 4 explores physical games and toys that support hands-on learning through simplified and tangible interactions. It focuses particularly on 3D-printable designs such as looms, moulds, and accessories, as well as their dissemination through online maker communities. The chapter illustrates how physical artefacts enable learners to grasp fundamental craft principles such as weaving, casting, and pattern-making, while also demonstrating the role of fabrication technologies in democratizing access to educational tools.

Chapter 5 – Educational Activities. This chapter presents structured educational activities that rely on improvised tools and everyday materials. By showcasing weaving with chairs, cardboard, and plates, papier-mâché sculpting, and storytelling-based activities, it demonstrates that meaningful craft education does not require sophisticated equipment. The emphasis is on creativity, adaptability, and experiential learning, reinforcing the idea that craft knowledge can be transmitted effectively in low-tech and informal settings.

Chapter 6 – Conclusions. The concluding chapter synthesises the findings of the deliverable and reflects on the broader implications for craft education and cultural heritage preservation. It highlights the strengths of game-based approaches, acknowledges limitations, and points toward future directions for research, development, and integration into educational and cultural institutions.

The annexes of Deliverable D4.3 provide essential supporting material that extends, substantiates, and operationalises the main body of the document. While the core chapters focus on conceptual framing, methodology, and selected case studies, the annexes supply detailed background research, technical documentation, educational resources, market analysis, and practical instructions. They ensure transparency, reproducibility, and reusability of the presented games, tools, and activities, supporting both academic scrutiny and practical adoption by educators, practitioners, and communities.

Annex A – Board Game Assets. Annex A presents the assets used during the design and implementation of Crafts, a board game created to educate and preserve traditional crafting techniques.

Annex B – Chess: Market Analysis. This annex presents a focused market analysis related to chess, addressing both onsite and online markets. It examines global market size, popular types of chess sets, sales channels, consumer demographics, seasonal trends, and the impact of technology. The analysis supports the use-case discussions in the main document by contextualising chess as a culturally embedded, craft-related object with both educational and commercial relevance, particularly in relation to physical fabrication and casting activities.

Annex C – Domestic Lab Notes. Annex C documents experimental notes from domestic laboratory activities involving the manufacture of soaps using 3D-printed moulds. It details materials (plasticine, clay, soap, wax), processes, and observed outcomes. These notes provide practical insight into the feasibility, limitations, and educational value of small-scale, home-based fabrication activities, reinforcing the deliverables' emphasis on accessible, hands-on craft education.

Annex D – Desk research catalogue: communities and 3D-printable craft-toy designs. This Annex reports a desk research activity that mapped online communities and repositories where makers share 3D-printable designs relevant to craft-related educational toys and games. The goal was (i) to identify designs that can be fabricated with common desktop FDM printers and used in informal learning settings, and (ii) to understand the "distribution ecology" (documentation norms, remix practices, and licensing patterns) that would affect reuse, adaptation, and dissemination of CRAEFT outcomes.

Annex E – Weaving. This annex presents alternative, low-tech weaving approaches using everyday objects such as chairs, cardboard, and plates. It also includes activities aimed at reinforcing counting and pattern recognition. Annex F supports Chapter 6 by demonstrating that craft education can be effectively delivered through improvised means, highlighting creativity and adaptability over technical sophistication.

Annex F – eLearning Tutorial: 3D Printable Designs. This annex offers guidance on locating, downloading, printing, and assembling 3D-printable designs from online communities. It functions as a practical manual for educators and learners who wish to implement the physical games described in the deliverable. Annex H strengthens the document's emphasis on openness, accessibility, and reuse.

Annex G – eLearning Tutorial: Casting Soap Chess Pieces. Annex G provides a complete eLearning tutorial for casting soap chess pieces using 3D-printed moulds. It includes materials, step-by-step instructions, worksheets, and a glossary, presented in both English and Greek. This annex exemplifies

how digital instructional content can support physical craft activities and illustrates the pedagogical integration of fabrication, play, and cultural artefacts.

Annex H – Expanding a Tapestry into a Script. The final annex explores storytelling and dramaturgic extensions of craft artefacts, demonstrating how a tapestry can be expanded into theatrical scripts, graphic novels, or cinematographic productions. It includes inventories of entities, narrative structures, and activity descriptions. This annex broadens the scope of craft education beyond material production, highlighting interpretative, narrative, and performative dimensions of cultural heritage.

Document history

Date	Author	Affiliation	Comment
1-6-2004	Nikolaos Partarakis and Xenophon Zabulis	FORTH	First version eLearning
1-7-2004	Nikolaos Partarakis and Xenophon Zabulis	FORTH	Updated version Apprentice-studio and Craft Studio
1-9-2004	Nikolaos Partarakis and Xenophon Zabulis	FORTH	Final version for internal review
30-9-2004	Nikolaos Partarakis and Xenophon Zabulis	FORTH	Final version with integration of the internal review comments

Abbreviations

Abbreviation	Full term
2D	Two-dimensional
3D	Three-dimensional
AAT	Art & Architecture Thesaurus
ABS	Acrylonitrile butadiene styrene
AI	Artificial intelligence
AR	Augmented reality
CAD	Computer-aided design
CCI	Cultural and creative industries
CH	Cultural heritage
CHI	Cultural heritage institutions
FIDE	International Chess Federation (Fédération Internationale des Échecs)
GAN	Generative adversarial network
ICH	Intangible cultural heritage
LLM	Large language model
MOP	Mingei Online Platform
MR	Mixed reality
NURBS	Non-uniform rational B-splines
OBJ	Wavefront OBJ (3D geometry file format)
PLA	Polylactic acid
PLY	Polygon File Format (Stanford PLY; 3D geometry file format)
PVA	Polyvinyl acetate (white glue)
QR	Quick response
RCI	Representative craft interface
STL	STereoLithography (3D geometry file format)
UI	User interface
UNESCO	United Nations Educational, Scientific and Cultural Organization
Unity	Unity game engine
URL	Uniform Resource Locator
VR	Virtual reality
WP	Work package
XR	Extended reality

Table of contents

1 Introduction

In the rapidly evolving landscape of education, innovative methods are continuously being explored to engage learners and impart knowledge effectively. One such promising approach is the use of games—both digital and physical—to educate individuals about traditional crafts. Traditional crafts, which encompass a wide range of skills and knowledge passed down through generations, are an integral part of our cultural heritage (CH). However, in today's digital age, these crafts face the risk of being forgotten. By leveraging the engaging and interactive nature of games, we can preserve and promote traditional crafts, ensuring they remain a living part of our culture.

Digital games, in this context, refer to two main types: simulators of crafting activities and simpler web-based games such as quizzes and 2D puzzles. Craft simulators provide a virtual environment where players can engage in crafting activities, allowing them to experience and learn the techniques involved in traditional crafts without the need for physical materials. Simpler web-based games, on the other hand, can include quizzes that test knowledge about traditional crafts or 2D puzzles that require players to solve problems related to these crafts, thereby reinforcing their learning through engaging challenges.

Physical games are another innovative approach, where games are designed to be downloaded and printed using a 3D printer. These games provide a tangible, hands-on experience, allowing learners to physically engage with materials and tools similar to those used in traditional crafts. This direct interaction can enhance the learning experience by providing a more realistic and immersive way to understand and practice these crafts.

Hybrid games combine the best of both digital and physical worlds. These games feature components that are both digital and physical, creating a more comprehensive and immersive learning experience. For instance, a hybrid game might involve a digital guide or tutorial paired with physical crafting materials printed on a 3D printer. This integration can help bridge the gap between virtual learning and real-world application, offering a multifaceted approach to educating about traditional crafts.

The purpose of this deliverable is to explore the potential of these different types of games—digital, physical, and hybrid—in educating individuals about traditional crafts. We will delve into the background of serious games, examine Craeft's approach to integrating traditional crafts into educational games, and provide insights into the design and implementation of these games. By doing so, we aim to highlight the innovative ways in which technology can be harnessed to preserve and promote our rich CH.

Traditional crafts are among the most fragile forms of CH. Unlike monuments or artefacts, which may be safeguarded through conservation, the survival of craft practices depends on the transmission of techniques, tacit knowledge, and embodied skills. When practitioners retire without successors, entire traditions risk being lost. This predicament has been amplified by industrialisation, the shift towards digital economies, and the declining number of apprenticeships in crafting. International policy frameworks, such as UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage (ICH) [58], emphasise the importance of preserving these living practices. Yet the practical question remains: how can the values, skills, and challenges of traditional craftsmanship be communicated to contemporary audiences in meaningful and engaging ways?

Gamification presents a viable solution. Games possess the inherent capacity to render intricate systems comprehensible by translating rules, constraints, and incentives into interactive experiences. Within the domain of CH, gamification has been strategically utilised to enhance the museum experience, support community engagement, and establish training environments that integrate entertainment with educational objectives. Board games are recognised for their tangible and social attributes. They stimulate collective player interaction with established rules and available resources, thereby creating environments where abstract concepts are externalised and rigorously examined through play. These inherent advantages position them as exceptionally well-suited for contexts demanding experiential and collaborative learning, as opposed to abstract and didactic approaches.

2 Positioning

2.1 Background of serious games

2.1.1 Definition and History

Serious games are designed with the primary purpose of achieving objectives beyond pure entertainment. These objectives can range from education and training [1] to health improvement [2] and social change [3]. The concept of serious games dates back to the early 1970s when the first educational games began to emerge. Initially, these games were simple and often limited in scope, but they laid the foundation for the development of more sophisticated and effective educational tools.

Over the years, the field of serious games has grown, incorporating advancements in technology and educational theory. Today, serious games are used across various industries, including education [4], healthcare [5], and military training [6]. They leverage the engaging and interactive nature of games to create immersive learning experiences that can effectively convey complex information and skills.

Serious Games in Education & Training

Serious and creative digital games have emerged as promising tools for learning and vocational training, supporting experiential engagement in both formal and informal contexts. These directions align with extensive research on serious games in education and training, which highlight their capacity to combine entertainment and instructional effectiveness [1, 6, 4, 7].

Health & Vocational Training

Comparable approaches in other domains confirm the value of serious games for skill acquisition. In healthcare, for instance, serious games have been widely deployed for rehabilitation, patient education, and professional training, demonstrating measurable benefits for complex competencies [2, 5]. These findings suggest similar advantages for vocational craft education.

Social Change & Interaction

Beyond training, serious games can function as instruments for cultural awareness and social change by embedding learning in social and collaborative contexts. Their effectiveness is closely tied to multimodal design and interactivity, which connect gameplay to learning outcomes [3, 8]. Recent studies also emphasise the importance of designing for meaningful social interaction and hybrid engagement protocols, which align closely with collaborative craft workshops [11, 12].

Experiential Learning & Feedback

Craft education emphasises learning by doing, where experimentation and problem-solving allow tacit knowledge to surface. This orientation resonates with research on experiential learning in serious games, which shows that active involvement deepens understanding, particularly when paired with effective feedback systems [9, 10].

2.1.1.5 Hybrid & Fabrication Games

The idea of combining digital games with physical toys and tangible craft experiences parallels research on hybrid and fabrication games. Scholars describe how mobile and digital technologies create hybrid spaces that harmonise physical and virtual domains [17, 18]. Similarly, fabrication games demonstrate how 3D printing and tangible play can open new pathways for learning and creativity [16].

2.1.1.6 Craft-Specific Simulation

In the textile domain, new digital tools such as Weavecraft illustrate the potential of interactive design and simulation for 3D weaving, bridging traditional practices with computational methods [13]. Such examples highlight the potential of craft-specific simulators to sustain and transform knowledge.

2.1.1.7 History & Spatial Games

Serious games have also been shown to support heritage and history education, enriching learning through interactive engagement [14]. Likewise, digital puzzle games can foster spatial visualisation and mental rotation skills, which are directly relevant to craft-based tasks requiring manual dexterity and 3D reasoning [15].

Games and toys offer a distinctive entry point into traditional crafts, translating complex manual processes into accessible, playful, and educational experiences. They have been widely studied in educational research, where they are recognised as tools that combine engagement with skill development [45, 51]. In the context of Craeft, games and toys provide a way to introduce learners of all ages to the principles of making, lowering the barrier to entry while retaining authenticity in the representation of craft knowledge.

2.1.2 Educational Benefits

The educational potential of serious games is vast, offering numerous benefits that can enhance the learning experience.

Engagement [7]	Games naturally captivate users' attention and motivate them to continue learning. This engagement is crucial for maintaining interest and encouraging sustained educational efforts.
Interactivity [8]	Serious games require players to actively participate in the learning process. This interactivity can lead to improved retention and understanding, as learners are more likely to remember information they have actively engaged with.
Experiential Learning [9]	Many serious games simulate real-world situations, allowing learners to practice skills and make decisions in a safe and controlled environment. This experiential learning approach helps learners apply theoretical knowledge in practical scenarios.

Immediate Feedback [10]	Games provide instant feedback on players' actions, helping them learn from mistakes and improve their performance. This immediate feedback loop is essential for reinforcing learning and correcting errors in real-time.

2.1.3 Digital Games

Digital games encompass a range of formats, from complex simulators to simpler web-based games such as quizzes and 2D puzzles [11]. Digital games can be considered as 'playable simulations,' allowing learners to interact with simplified versions of real-world processes. Prior initiatives demonstrate this potential: the Virtual Loom developed in the SilkNow project recreated textile weaving processes in a digital environment, while commercial products such as Woodwork Simulator illustrate how realistic digital physics can be used to simulate manual operations. More broadly, serious games have been systematically applied in vocational training to develop procedural skills [47, 44]. These approaches highlight how digital games may support the teaching of sequential craft actions, reinforce procedural memory, and encourage repetition without the material costs of workshop training. In Craeft, the Apprentice Studio and Craft Studio environments provide a foundation for designing such games, enabling craft-specific digital experiences that combine authenticity with playability.

2.1.3.1 Craft Simulators

These games provide virtual environments where players can engage in crafting activities. For example, a weaving simulator might allow players to practice different weaving techniques on a virtual loom [13]. These simulators offer a high degree of realism and interactivity, making them effective for teaching complex skills. By replicating the tools and processes used in traditional crafts, simulators can provide an immersive learning experience without the need for physical materials.

Pottery simulators can be grouped into three strands. First, mid-air freeform pottery systems demonstrate accessible “hands-first” creation without a wheel, using depth sensing to infer hand intent and deform a vessel in real time; studies report fast onboarding and high engagement, while also surfacing practical issues such as tracking accuracy, ergonomics, and the need for clearer depth feedback [53]. Second, parametric/scripted tools support rapid exploration of pottery families by exposing mathematical parameters and CAD-grade surface representations (e.g., NURBS), but they primarily target conceptual design rather than the motor learning of wheel throwing [55]. Third, platform-oriented approaches combine VR creation with cloud persistence and asynchronous exhibition halls, emphasising sharing and dissemination rather than practice-aligned instruction [56]. AI-augmented MR has explored guidance during physical wheel throwing by overlaying holograms and delivering real-time feedback, highlighting personalised coaching and limitations in conveying tacit cues and ensuring robust recognition [52].

2.1.3.2 Web-Based Games

Simpler digital games, such as quizzes and 2D puzzles, can also be valuable educational tools [14, 15]. Quizzes can test players' knowledge about traditional crafts, reinforcing learning through repetition and feedback. For instance, a quiz game might challenge players to identify different types of weaving patterns or pottery styles. 2D puzzles might involve solving problems related to crafting processes and helping players understand the steps and skills involved. These games are often accessible and easy to use, making them ideal for a broad audience.

2.1.4 Physical Games

Physical games provide a hands-on learning experience through tangible components that can be downloaded and printed using a 3D printer.

Physical toys represent a complementary route, aligning with long-standing traditions of educational play. Within the constructionist paradigm [49], learning occurs through making, experimenting, and iterating on physical artefacts. Toys such as modular construction kits, simplified tool replicas, or small-scale material kits allow learners to rehearse the fundamental principles of shaping, joining, or interlocking materials. Research in child development and educational design [42, 50] underscores the capacity of such toys to scaffold creativity while also embedding tacit knowledge. Within Craeft, the opportunity exists to develop physical toys that replicate simplified craft workflows, for example, 3D-printed mould-making sets, which enable safe and low-cost engagement with traditional techniques.

3D Printed Games offer physical components that players can interact with [16], such as replicas of traditional crafting tools or materials. For example, a game might include 3D-printed pieces that replicate the tools used in pottery or weaving. By physically handling these components, learners can gain a better understanding of the tools and techniques used in traditional crafts. This tactile interaction can enhance the learning experience by providing a more realistic and immersive way to understand and practice these crafts.

Board and Card Games can also be adapted to teach about traditional crafts. These games might include elements that mimic crafting processes or require players to apply knowledge about crafts to progress in the game. For instance, a board game might involve collecting resources and using them to create various craft items, simulating the steps involved in traditional crafting.

2.1.5 Board games for CH transmission

Crafts demonstrates the potential and the challenges of board games for CH transmission. The findings are considered in relation to the game and against the backdrop of research on gamification, educational games, and craft safeguarding.

2.1.5.1 Transmission

The transmission of CH through analogue and digital games has been documented as an avenue for experiential learning [1, 6, 4, 7]. Comparable approaches in other domains confirm the value of serious games for skill acquisition. In healthcare, for instance, serious games have been widely deployed for rehabilitation, patient education, and professional training, demonstrating measurable benefits for complex competencies [2, 5]. These findings suggest similar advantages for vocational craft education.

2.1.5.2 Pedagogical Affordances

Beyond training, serious games can function as instruments for cultural awareness and social change, embedding learning in social and collaborative contexts [3, 8]. Their effectiveness is closely tied to multimodal design and interactivity, which connect gameplay to educational outcomes. Recent studies

also emphasise the importance of designing for meaningful social interaction and hybrid engagement protocols, which align closely with collaborative craft workshops [11, 12].

2.1.5.3 Analogue–Virtual Duality

A defining quality of the Crafts prototype is the duality of analogue and virtual formats. This hybrid mode aligns with broader trends in serious game design, where physicality and embodiment enhance learning outcomes [46, 47, 48]. Analogue play fosters tactile engagement and material resonance, while digital play provides scalability, remote accessibility, and seamless data integration. Together, they expand the pedagogical space beyond the limitations of either format in isolation.

2.1.5.4 Sustainability

Sustainability here refers to both the durability of the medium and its capacity for long-term integration into craft education. Serious games have been shown to enhance retention by embedding knowledge in memorable experiences [45, 49]. The replayability and adaptability of Crafts enable repeated engagement across various contexts, ensuring continuity of learning and learning outcomes. Moreover, serious games in CH contexts increasingly highlight the importance of authenticity and contextualisation, ensuring that sustainability is not only technical but cultural [43, 41].

2.1.5.5 Hybrid Games

Hybrid games combine digital and physical elements, providing a comprehensive and immersive learning experience [12].

A hybrid game might involve a digital tutorial or guide paired with physical crafting materials. For example, a game could include a digital app that walks players through the steps of a craft project, while they use 3D-printed tools and materials to complete the project in the real world. This combination helps learners bridge the gap between virtual instruction and hands-on practice, offering a multifaceted approach to educating about traditional crafts.

AR technology can enhance hybrid games by overlaying digital information onto the physical world [17, 18]. For instance, an AR game might display virtual crafting instructions or tips overlaid on the physical workspace, helping learners follow along and understand the process more clearly. This integration of digital and physical elements can create a seamless learning experience that leverages the strengths of both formats.

A particularly promising direction is the integration of physical toys with digital systems, creating hybrid applications. Tangible user interface (UI) research [46] demonstrates that embodied interaction, using hands and physical artefacts, can be enhanced by real-time computational feedback. Hybrid craft toys may therefore act as tangible interfaces for eLearning modules: a child manipulating a toy loom, for example, could see their movements reflected and extended in a digital environment, creating an interplay of tactile engagement and virtual augmentation. This synergy allows learners to appreciate both the 'feel' of materials and the broader conceptual logic of craft processes.

2.1.6 Conclusion

Beyond education, games and toys inspired by crafts carry potential as cultural products in their own right. They may support new income streams for practitioners, create jobs in toy and game development, and generate digital assets for use in broader cultural and creative industries (CCIs). As observed in previous studies on serious games and CH [43, 48], playful media formats can extend engagement beyond specialist audiences, reaching younger demographics and the general public.

Serious games offer a powerful and versatile approach to education, particularly in the context of traditional crafts. By harnessing the strengths of digital, physical, and hybrid games, educators can create engaging, interactive, and effective learning experiences. These games not only help preserve and promote traditional crafts but also ensure that these important cultural practices continue to thrive in the modern world. In the following sections, we will explore Craeft's approach to integrating traditional crafts into educational games and provide insights into the design and implementation of these games.

2.2 The proposed approach

Our approach to using games, toys, and activities for knowledge transmission is centred on the goal of fostering a deeper understanding of crafting activities as the interaction between the mind and matter.

Our approach to creating educational games involves simplifying complex and detailed research outcomes into accessible and engaging formats suitable for children. By distilling the essence of traditional crafts into game mechanics, we aim to introduce young learners to these practices in a way that is both fun and educational.

For example, the pottery simulator we developed is a mass-preserving simulator that can mimic the results of practitioner actions on clay. By using this simulator, children can learn about the basic techniques of pottery making in an interactive and immersive manner. The simulator simplifies the complex actions of a skilled potter into manageable steps that children can follow and understand.

Similarly, our jewellery box immersion game uses ultra-high-resolution digitisation to create a virtual environment where users can explore and appreciate the intricate details of a silver bracelet. The game simplifies the concept of jewellery making into an exploratory adventure, allowing children to learn about the craft through visual and interactive engagement.

The potholder loom game exemplifies how physical games can introduce children to the art of weaving. By using a 3D printed loom and elastic loops, children can learn the basics of weaving while engaging in a hands-on activity.

The ultimate goal of our approach is to make traditional crafts accessible and engaging for a younger audience. By leveraging modern technologies such as 3D printing, high-resolution digitisation, and interactive simulations, we bridge the gap between ancient practices and contemporary learning methods. Our games not only teach children the technical aspects of crafts but also instil an appreciation for the cultural and historical significance of these practices.

Through this innovative approach, we aim to ensure that the knowledge and skills associated with traditional crafts are preserved and passed on to future generations. By introducing children to these crafts through simplified and engaging games, we foster a new generation of learners who value and continue the rich traditions of craftsmanship.

In conclusion, our approach combines thorough research, advanced technology, and creative simplification to create educational games that effectively teach traditional crafts. By systematically understanding and documenting crafts, generating detailed data and simulations, and transforming this information into accessible games, we provide a unique and impactful educational experience.

2.1 Step 1 - Systematic Understanding of Crafts

Our approach to educating about traditional crafts is grounded in a comprehensive and systematic understanding of these practices. This understanding is achieved through a multi-faceted process that includes documentation, video elicitation, ethnography, simulation of craft actions, and digitisation of craft materials and products.

Documentation involves capturing detailed records of traditional crafts, including the tools, materials, techniques, and processes used by practitioners. This can take the form of written descriptions, photographs, and technical drawings, all of which contribute to a thorough archive of craft knowledge.

Video Elicitation is employed to document and analyse the actions of craftsmen. By recording practitioners at work, we capture the nuances of their techniques and the subtleties of their skills. These videos serve as valuable resources for both preserving and teaching traditional crafts.

Ethnography allows us to delve deeper into the cultural and social contexts of crafts. Through immersive fieldwork, we gain insights into the traditions, values, and communities that sustain these practices. This holistic understanding enriches our educational content, ensuring it is not only technically accurate but also culturally resonant.

Simulation of Craft Actions involves creating virtual models that replicate the movements and techniques of craftsmen. For instance, a pottery simulator is designed to mimic the effects of a practitioner's actions on clay, providing users with a realistic and interactive experience of pottery making. These simulations are powerful tools for preserving the intricate skills of craftsmen and making them accessible to a wider audience.

Digitisation of Craft Materials and Products entails creating high-resolution digital representations of crafted items. This includes detailed 3D models and textures that capture the essence of materials like silver, clay, and textiles. These digital assets are crucial for creating accurate and engaging educational games.

2.2 Step 2 - Generating Knowledge and Data

The systematic documentation and digitisation activities carried out in Step 1 produce a rich, multimodal corpus of knowledge and data about traditional crafts. This corpus forms the empirical foundation upon which all educational games and tools developed within CRAEFT are built, ensuring that every learning resource is grounded in authentic, rigorously collected, and formally represented craft knowledge.

Multimodal Craft Datasets: The knowledge generated spans multiple modalities and levels of representation. At the signal level, datasets include photographic and three-dimensional documentation of tools, workspaces, intermediate and final products, high-resolution surface scans of artefacts, four-dimensional recordings of practitioner motion and material deformation, and haptic recordings of craft actions. At the semantic level, crafting activities are decomposed into actions and process schemas, each annotated with parameters such as force, incidence angle, and speed, and linked to digital assets through the CRAEFT Authoring Platform (CAP). Contextualisation narratives, formally encoded as events in CIDOC-CRM and the Europeana Data Model (EDM), capture the technological, social, historical, and aesthetic dimensions of each Representative Craft Instance (RCI), ensuring that the knowledge generated is not only technically accurate but also culturally situated.

The Maker–Material–Negotiation Model: A central output of this step is the formalisation of the Maker–Material–Negotiation ontology, which provides a unified semantic framework for representing the full range of crafting activities across materials and techniques. Within this model, actions are classified into four elementary types, Add, Subtract, Interlock, and Transform, and associated with affordances, conditions, material effects, and the mental imagery that guides a practitioner's decision-making. Action

plans are represented as generative hypotheses: formal descriptions of the anticipated result of an action, against which the practitioner's sensory feedback is compared during execution. This formal structure makes tacit knowledge computable and reusable across different craft contexts, supporting both simulation and educational application.

Training Datasets for Simulation: The annotated multimodal recordings are organised into training datasets that associate semantic representations of actions and plans with their material expression, including practitioner force and motion, tool manipulation, artefact geometry, and material transformation events. These datasets serve a dual purpose: they populate the Maker–Material–Negotiation ontology in the CAP, making craft knowledge accessible through Semantic Web and Europeana infrastructure, and they provide the training data required to instantiate and refine craft-specific action simulators from archetypal models. The comparative design across eight RCIs, spanning the full range of materials and action types, ensures that the datasets capture both the common principles and the material-specific variations of crafting techniques.

Digital Assets and Knowledge Infrastructure: All digital assets, metadata, and semantic representations are stored and managed through the CAP, an extension of the Mingei Online Platform. Craft vocabularies are linked to the Getty and UNESCO thesauri, with novel entities encoded in SKOS, ensuring alignment with international standards and long-term accessibility. The resulting knowledge infrastructure, encompassing ontology entities, process schemas, action plans, digitised artefacts, and contextualisation narratives, provides the structured, research-driven foundation from which educational content and game mechanics are subsequently derived in Step 3.

2.3 Step 3 - Simplification and Game Development

Our approach to creating educational games involves simplifying complex and detailed research outcomes into accessible and engaging formats suitable for children. By distilling the essence of traditional crafts into game mechanics, we aim to introduce young learners to these practices in a way that is both fun and educational.

For example, the pottery simulator we developed is a mass-preserving simulator capable of mimicking the results of practitioner actions on clay. By using this simulator, children can learn about the basic techniques of pottery making in an interactive and immersive manner. The simulator simplifies the complex actions of a skilled potter into manageable steps that children can follow and understand.

Similarly, our jewellery box immersion game uses ultra-high-resolution digitisation to create a virtual environment where users can explore and appreciate the intricate details of a silver bracelet. The game simplifies the concept of jewellery making into an exploratory adventure, allowing children to learn about the craft through visual and interactive engagement.

The potholder loom game exemplifies how physical games can introduce children to weaving simply and tangibly. By using a 3D-printed loom and elastic loops, children can learn the basics of weaving while engaging in a hands-on activity.

2.4 Step 4 - Educational Impact

The ultimate goal of our approach is to make traditional crafts accessible and engaging for a younger audience. By leveraging modern technologies such as 3D printing, high-resolution digitisation, and interactive simulations, we bridge the gap between ancient practices and contemporary learning methods. Our games not only teach children the technical aspects of crafts but also instil an appreciation for the cultural and historical significance of these practices.

Through this innovative approach, we aim to ensure that the knowledge and skills associated with traditional crafts are preserved and passed on to future generations. By introducing children to these crafts through simplified and engaging games, we foster a new generation of learners who value and continue the rich traditions of craftsmanship.

In conclusion, our approach combines thorough research, advanced technology, and creative simplification to create educational games that effectively teach traditional crafts. By systematically understanding and documenting crafts, generating detailed data and simulations, and transforming this information into accessible games, we provide a unique and impactful educational experience.

3 Digital games

3.1 Introduction

Digital games represent a powerful and versatile medium for transmitting craft knowledge to broad and diverse audiences. Unlike static documentation or passive observation, digital environments allow learners to engage directly with craft processes, manipulating tools, shaping materials, and receiving immediate feedback, in ways that are safe, repeatable, and free from the constraints of physical workshops. This chapter presents a suite of digital games developed within the CRAEFT project, each designed to make a distinct traditional craft accessible through interactive and immersive digital experiences.

The games presented in this chapter follow two complementary educational strategies. The first emphasises procedural learning through embodied interaction: learners engage with simulated tools and materials to develop an understanding of the sequential actions, decisions, and skills involved in craft production. The second strategy emphasises perceptual appreciation through scale and resolution: by situating learners within digitised craft artefacts at unprecedented levels of detail, the games foster a deep visual and spatial appreciation of craftsmanship that would be difficult to achieve through conventional means.

Four digital games are documented in the sections that follow. **Section 3.2** presents the 3D Pottery Workshop, a mouse-controlled simulation that immerses users in a virtual pottery studio where they can shape clay on a virtual wheel, following step-by-step guidance through the fundamental techniques of wheel-throwing. **Section 3.3** introduces the XR Pottery Workshop, a VR-first experience designed for the Meta Quest 3 headset, which offers a more advanced and embodied simulation of wheel-thrown pottery with a compact toolkit of sculpting and painting tools, explicit workflow modes, and exportable outputs for critique and portfolio use. **Section 3.4** describes The Jewellery Box, an immersive first-person experience built on ultra-high-resolution digitisation of a silver bracelet, where users are transported into a virtual jewellery box and invited to explore the intricate details of the piece at miniature scale. Finally, **Section 3.4** also presents the Lathe Woodturning Game, a Unity3D-based simulator where players interact with virtual chisels to reproduce target patterns on a rotating wooden blank, learning the basic principles of tool selection and material subtraction.

3.2 3D pottery workshop

One of the digital games we have developed focuses on the traditional craft of pottery making. This game immerses users in a virtual 3D traditional craft workshop, providing an environment where they can explore and interact with various elements of pottery crafting. The workshop is meticulously designed to replicate the atmosphere and tools of a real pottery studio. Users can navigate through the workshop, observing different tools, materials, and pottery pieces at various stages of completion. This immersive environment helps users feel as though they are genuinely part of a traditional craft setting, enhancing the overall educational experience.

At the heart of the workshop is the pottery wheel simulation. In the first version of the game, users interact with the pottery wheel using their mouse to control the "tool." This simulation allows users to

engage in the intricate process of shaping clay, providing a realistic experience of crafting a pottery piece from start to finish. The mouse control system is designed to be intuitive, enabling users to manipulate the clay with precision. By moving the mouse, users can apply different pressures and movements to shape the clay, simulating the tactile feedback experienced in real pottery making. The game incorporates realistic feedback mechanisms, such as changes in the shape and texture of the clay in response to user input. This feedback helps users understand the impact of their actions, making the learning experience more authentic.

To assist beginners, the game includes step-by-step instructions and visual guides. These guides walk users through the fundamental techniques of pottery making, such as centring the clay, opening it up, and pulling up the walls to form the desired shape. Users have the freedom to experiment with different shapes and designs, allowing them to express their creativity. The game also offers various tools and brushes that can be used to add intricate details and patterns to the pottery.

The primary educational objective of this digital game is to teach users the basic techniques and principles of pottery making. By providing a hands-on, interactive experience, the game aims to enhance users' understanding of the pottery-making process, from preparing the clay to finishing the final piece. The simulation helps users develop their motor skills and hand-eye coordination, which are essential for real-world pottery making. Moreover, the game encourages users to explore different techniques and styles, fostering a sense of creativity and innovation.

User feedback has been instrumental in refining the game and enhancing its educational value. Players have appreciated the realistic feel of the simulation and the ability to experiment with different techniques. Based on this feedback, future versions of the game will include more advanced control options, such as touch-screen interfaces and VR support, to provide a more immersive experience. Additionally, more detailed tutorials and tips for advanced techniques will be added to cater to users with varying levels of expertise. Enhancements to the graphics and physics engine will make the simulation even more lifelike, including the addition of texture variations and more detailed clay behaviour.

In conclusion, the digital pottery-making workshop is an innovative educational tool that combines the engaging nature of gaming with the rich tradition of pottery-making. By offering a realistic and interactive experience, this game not only preserves the craft but also makes it accessible to a broader audience, ensuring that the art of pottery continues to thrive in the digital age.

Figure 1. The pottery workshop mini-game

Game download: Partarakis, N., Zabulis, X., & Koutlemanis, P. (2025). Pottery wheel throwing. doi 10.5281/zenodo.18106951

3.3 XR pottery workshop

Wheel-thrown pottery is an embodied skill: timing, pressure, and rhythm matter as much as geometry. In traditional studio teaching, repeated practice is constrained by access to equipment, consumable materials, safety considerations, and scheduling. At the same time, training contexts increasingly benefit from reviewable digital artefacts that support critique, iteration, and portfolio building.

Prior digital pottery systems typically trade off realism, pedagogy, and logistics: mid-air “virtual clay” systems are approachable but omit wheel dynamics; parametric tools accelerate shape exploration but bypass tacit motor learning; and mixed-reality systems can augment physical wheels but still inherit studio constraints. The Extended Reality (XR) pottery workshop addresses this gap by offering a wheel-centric, instruction-ready environment that is safe, repeatable, and portable.

The system is an XR platform with a VR-first interaction model, designed for the Meta Quest 3 headset. Users shape a continuously rotating virtual clay body with a compact suite of tools, may explicitly transition to a painting phase, and can export their results for downstream use.

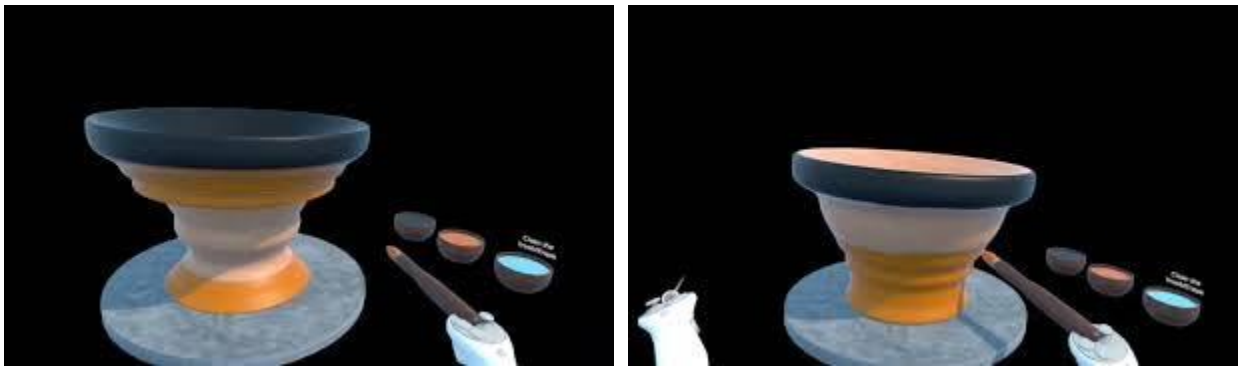


Figure 2. Game demonstration in VR with a black virtual background. Videos: https://youtu.be/3YEJYko7lY0 (left) and https://youtu.be/W63ykw3k6cA (right).

The software architecture is intentionally minimal: a master clay mesh shared by rendering, tools, painting, and export; a wheel controller that regulates speed and gates sculpting by rotation state; an explicit mode manager that enforces a clear separation between sculpting and painting; and an in-headset wrist menu that exposes session-level actions, Export, Restart, and Handedness (Figure 3, 1–4).

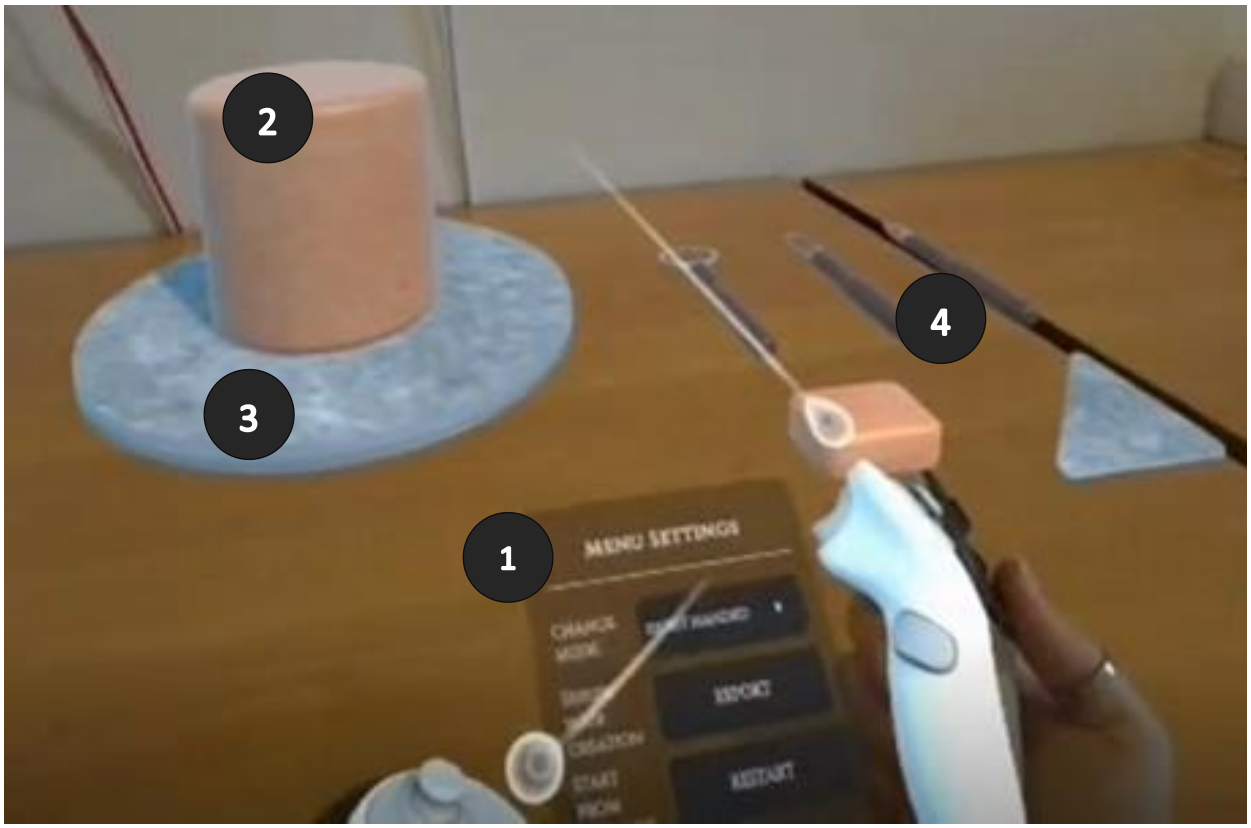


Figure 3: Workspace overview (numbered), using real-life augmented background: The in-headset workspace with (1) wrist system menu, (2) clay, (3) base/wheel, and (4) pottery tools (ribbon tools, Rib Tool, Additive tool, paintbrush).

At the heart of the application is one master 3D mesh that represents the clay (Figure 3-2). Rendering, tools, painting, and export all operate on this same mesh. In practice, that means when a tool changes

the form, the on-screen model and the exported files are guaranteed to match; there are no duplicate or "out-of-sync" copies of the clay in memory. The mesh is produced by the native RevolutionSolid geometry generator and accessed from Unity via managed bindings on both Windows (Editor) and Quest/Android.

A virtual base anchors the scene and controls the wheel's state—idle, spinning, speed (Figure 3-3). The clay inherits the base transform each frame, so the visual motion and the geometry kernel remain synchronised. Users can start and pause speed; acceleration and deceleration are deliberately smooth to support precision work and comfort. A subtle spinning audio cue plays only while the base is rotating to reinforce the motion state and perceived speed.

Sculpting is gated by spin to encode studio practice: if the base is stopped and the user reaches for a sculpting tool, the system blocks tool activation and instructs the user to start the wheel; when the base spins, the manager re-enables tool IDs so shaping proceeds in stable, repeatable passes. This rule reduces errors and teaches the "spin first" habit.

The implemented toolkit is intentionally compact and covers the core manipulations used in real-world pottery practice (see Figure 3-4).

1. **Additive Tool** – builds up material around the form during rotation (see Figure 4).
2. **Ribbon Tools** – subtract material for shaping and detail (see Figure 5).
3. **Shaping Tool** – redistributes volume without adding or removing clay; currently operated with the left hand/controller (Two-handed support is planned.)
4. **Rib Tool** – smooths the surface and refines profiles during rotation (see Figure 4).

When a user grabs any tool, a brief floating label confirms which one is active, reducing selection mistakes and making demonstrations easier to follow.

Figure 4: Shaping sequence on the spinning wheel: build-up with the Additive Tool ("block of clay"), followed by smoothing and profile refinement with the Rib Tool.

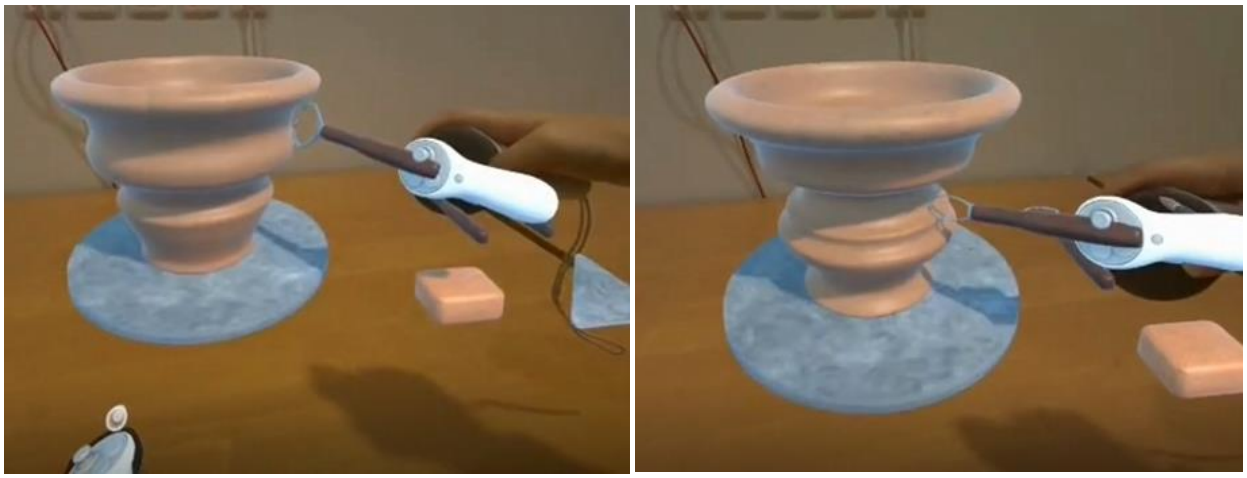


Figure 5: Subtractive shaping with Ribbon Tools.

3.3.1 Explicit workflow modes

To keep the workflow legible and to match studio habits, the system uses two modes:

1. **Sculpting mode**. Sculpting tools and relevant UI are available; painting elements stay out of the way.
2. **Painting mode**. Triggered when the user picks up the brush and confirms a pop-up (see Figure 6). Upon entry, the clay becomes slightly lighter, suggesting a “dry” stage suitable for decoration, and all sculpting tools are disabled.

The system defers the brush pop-up until the wheel has spun at least once in the session; if the user tries to paint too early, a spin-based hint explains how to begin correctly.

Figure 6: Switch to Painting confirmation: A pop-up that confirms the explicit transition from Sculpting to Painting.

Decoration is applied directly to the same clay mesh using vertex colours; the shader blends the base material with the per-vertex colour, so strokes appear instantly, and there is no texture baking step. Colours are chosen from in-scene jars, a water jar clears the brush and also erases colour from the vessel (see example in Figure 9), and the brush visuals always reflect the active colour, so the user sees what will be applied before touching the surface. The brush initialises with a transparent colour; if no colour is chosen, painting does nothing, preventing accidental marks.

Figure 7: Painting mode with colour jars: On entering Painting, the clay lightens ("dries"), sculpting tools are disabled, and the brush applies vertex colours selected from the jars.

The wrist menu (see Figure 3-1) is available anywhere in the scene for consistent session control:

- **Export**. Saves timestamped files to the headset. In Sculpting, it writes OBJ (geometry); in Painting, it writes OBJ + PLY (geometry plus vertex colours) for fabrication or portfolio use.
- **Restart**. Shows a confirmation dialogue and, if accepted, returns to a clean state (fresh clay, default speed, tools reset).
- **Ambidextrous Design**. Toggles Right- or Left-handed layouts and control mappings so tools and UI sit on the user's dominant side without leaving the session.

3.3.2 User interaction flow

- **Enter and orient**. The user raises the wrist, reviews the menu, and starts the base; the spinning sound confirms motion. If they grab a sculpting tool while stopped, a prompt teaches them to start the wheel first.
- **Shape while spinning**. Additive and ribbon tools build and refine the profile; the Mass-Preserving Tool moves volume without changing total mass; the Rib Tool smooths at controlled speeds (see Figure 4). Floating labels prevent tool confusion (Figure 8).
- **Switch modes explicitly**. Picking up the brush opens a confirmation; on acceptance, the system enters Painting, the clay lightens to indicate "dry," and sculpt tools are disabled (see Figure 6).
- **Decorate**. The user chooses colours from jars, paints directly on the mesh, uses the water jar to erase where needed (see Figure 9), and always sees the active colour on the brush tip.
- **Finish and export**. From the wrist menu, the user exports: OBJ in Sculpting; OBJ + PLY in Painting, both timestamped for galleries, critique, or 3D printing.

Illustrative user scenarios

Alex (novice, right-handed) typically begins by reaching for a tool too early; the system intervenes with a short prompt that the wheel must be spinning first. He follows a basic centring/opening/pulling workflow with additive and ribbon tools, and if he over-subtracts and destabilises the form, he uses Restart to recover quickly. After a successful second attempt, he exports the sculpted geometry (OBJ) for later critique.

Maria (intermediate, left-handed) starts by toggling Handedness so the UI and tool placements match her dominant side. She shapes the vessel, then switches explicitly to Painting, applies banded decoration, and uses the water jar to erase excess colour before refining the final pattern. She exports geometry plus vertex colours (OBJ+PLY) for portfolio use.

3.3.3 Comfort, feedback, and safety

Smooth acceleration profiles, stable frame times, and clear state cues (wheel audio; lighter clay in Painting; tool labels) support long practice sessions.

Restart provides a safe recovery path when a piece goes wrong, so mistakes do not compound across the session. Planned haptics will later complement audio for contact and pressure cues.

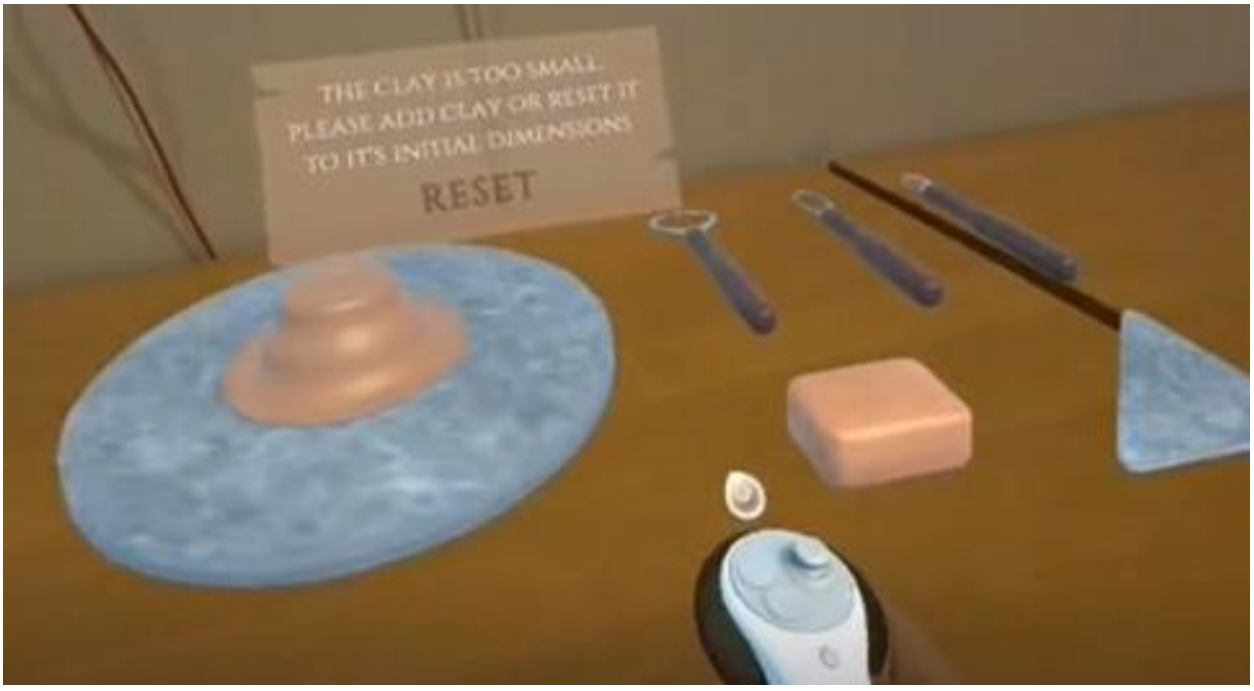


Figure 8: Safety prompt: clay too small → Reset: System feedback and recovery path when the piece is over-reduced.

During Painting, users can also correct surface-colour mistakes *on the spot* by clearing the brush in the water jar and erasing applied paint.

3.3.4 Future work

Planned extensions

Beyond the current prototype, the next development cycle targets (i) stronger pedagogy through step-by-step lessons with gated progression and optional audio/voice guidance, with role/difficulty support (student vs instructor); and (ii) higher craft fidelity and review workflows through point-specific clay addition, controller haptics for tool–clay contact, and true bimanual mass-preserving manipulation. To support iterative learning, planned features also include save/load via a personal gallery, template starting forms (e.g., amphora, kylix, pyxis), and undo/redo for sculpting and painting. Finally, contextual notes and optional 3D reference overlays are envisioned, alongside accessibility options such as colour-blind-friendly palettes and high-contrast modes.

Limitations and roadmap

Though the XR pottery workshop is intentionally scoped for safe, repeatable practice and exportable outputs, key limitations remain: clay addition is circumferential rather than point-specific, haptics are not yet provided, and bimanual mass-preserving shaping is limited. A structured lesson layer (sequenced steps, gated progression, and role-aware prompts) is also not yet integrated. These gaps define a clear roadmap that advances along two axes: strengthening pedagogy (lessons, assessment, save/load and review workflows) and increasing craft fidelity (localised addition, haptics, bimanual shaping, and optional physical anchoring), moving the prototype from a practice studio towards a full teaching tool suitable for formal evaluation.

Figure 9: Erase with water. Using the water jar to erase, the decorated vessel with black/orange/white bands.

3.4 The jewellery box

The second digital game we have developed is a unique and immersive experience based on the concept of a user being transported into a jewellery box. This game leverages cutting-edge research in ultra-high-resolution digitisation of shiny materials to create a visually stunning and educational environment. At the core of this experience is the digitisation of a silver bracelet, captured in extreme detail to showcase the delicate binding of silver strings and the exquisite workmanship of the jeweller.

The game situates the digitised bracelet within a virtual jewellery box, where the user assumes the role of a first-person adventurer exploring this intricate environment. The ultra-high-resolution digitisation allows users to experience the fine details of the bracelet up close, appreciating the craftsmanship and intricate designs that are often difficult to observe with the naked eye.

As the user navigates through the jewellery box, they can walk on the bracelet itself, providing an unprecedented perspective on the artistry involved in its creation. The virtual environment is designed to be highly interactive, with various vantage points and areas for the user to stand. These elevated spots offer panoramic views of the bracelet, allowing users to gain a comprehensive understanding of its structure and design.

The game's environment is crafted to enhance the user's sense of immersion. As the adventurer walks through the jewellery box and across the bracelet, they can inspect the intricacies of the silver strings, observe the fine details of the patterns, and appreciate the jeweller’s meticulous work. The lighting within the virtual box is carefully designed to highlight the reflective qualities of the silver, enhancing the visual appeal and realism of the experience.

Educationally, this game aims to provide users with a deeper appreciation of traditional jewellery-making techniques. By offering an interactive and detailed exploration of a high-quality piece of jewellery, the game helps users understand the level of skill and precision required in this craft. It also emphasises the beauty and value of traditional craftsmanship, encouraging users to appreciate and preserve these artisanal skills.

User feedback has played a crucial role in shaping this game. Players have expressed awe at the level of detail and realism achieved through the ultra-high-resolution digitisation. The ability to explore the bracelet from a first-person perspective and view it from various angles has been particularly well-received. Future iterations of the game will aim to expand the variety of digitised jewellery pieces, offering users the opportunity to explore different styles and techniques from various cultures and historical periods. Additional features such as interactive tutorials and historical context about the jewellery pieces will further enrich the educational experience.

In conclusion, the jewellery box immersion experience is an innovative digital game that combines advanced digitisation technology with interactive learning. By allowing users to explore a meticulously crafted piece of jewellery in a virtual environment, the game not only highlights the artistry of traditional jewellery making but also makes this heritage accessible to a broader audience. This immersive approach ensures that the appreciation for such intricate craftsmanship continues to thrive in the digital age.

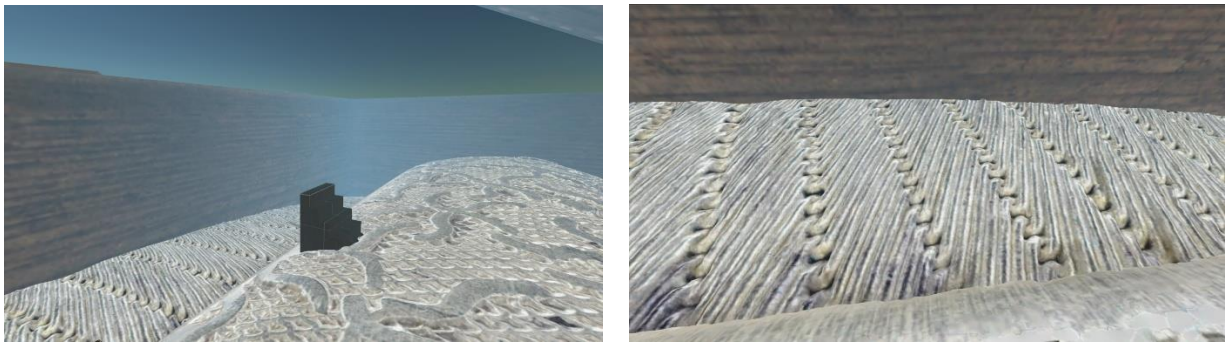


Figure 10. The jewellery box mini-game – different views of the silver bracelet

Game download: Partarakis, N., Zabulis, X., & Koutlemanis, P. (2025). Explore a 3D reconstruction of a silver bracelet. doi: 10.5281 /zenodo.18106078

3.4 Lathe woodturning game

A wood-turning game was implemented in Unity3D as an introductory tool for familiarising players with the operation of a wood-turning lathe. The virtual environment simulates a rotating wooden blank mounted on a digital lathe, where players interact using a set of virtual chisels. Each chisel is represented with distinct geometry and cutting properties, emulating its real-world counterpart.

During gameplay, a target pattern is projected directly onto the rotating wood surface, serving as a guide for the carving task. Players must select the appropriate chisel, position it correctly, and manipulate it along the X- and Z-axes to gradually remove material and reproduce the projected design. The system dynamically updates the 3D mesh of the wooden blank in real time, applying vertex/mesh deformation techniques to simulate material subtraction as the tool interacts with the object.

Collision detection is handled through Unity's physics engine, ensuring that only the active contact areas of the chisel affect the wood. The visual rendering uses dynamic lighting and shading to highlight the carved areas, while particle effects (such as wood shavings) can be integrated to enhance realism. User interaction can be performed via mouse and keyboard.

This game serves as an engaging learning activity and as a simplified training simulator, demonstrating the basic principles of wood-turning, tool selection, and pattern reproduction in a controlled and interactive digital environment. Examples from the gameplay are presented in Figure 11.

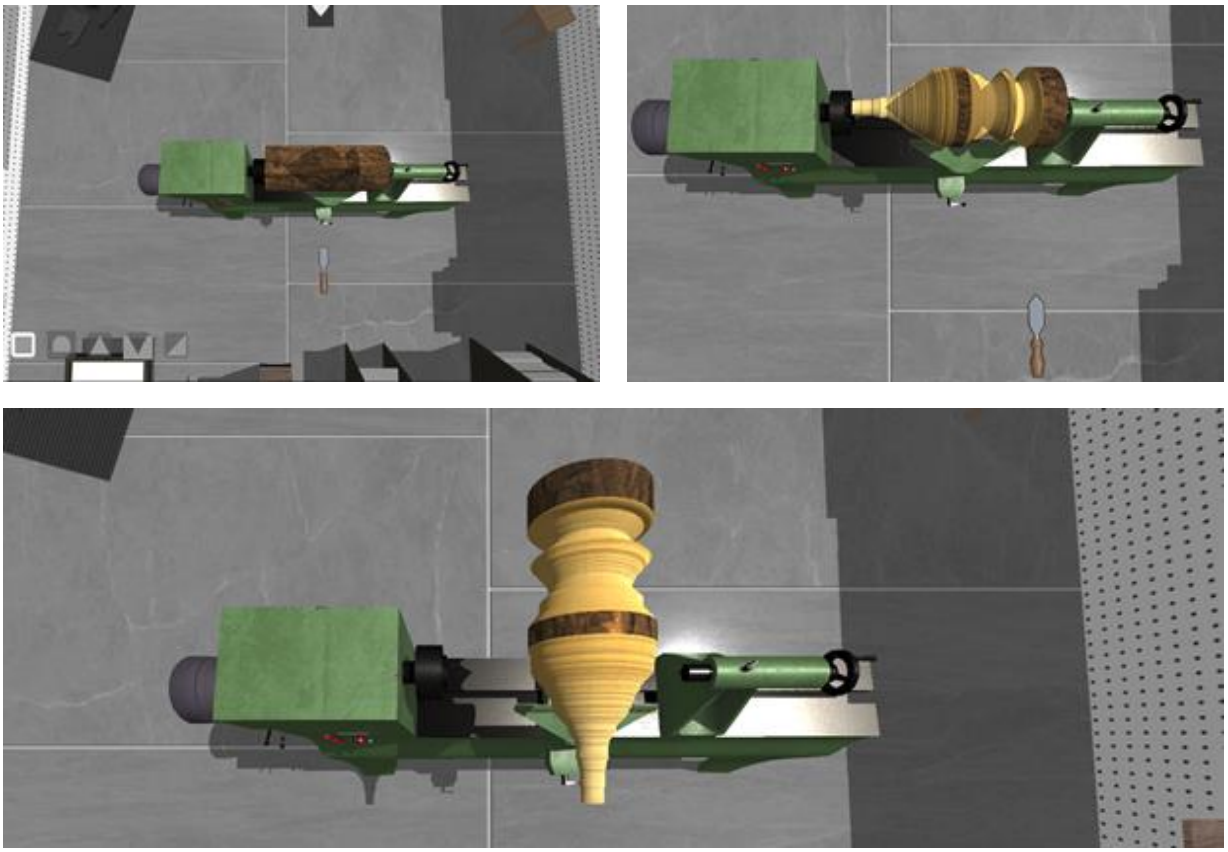


Figure 11. Woodturning process and resulting piece

Game download: Partarakis, N., & Zabulis, X. (2025). WoodTurning game. doi. 10.5281/zenodo.18101748

3.5 Conclusion

The digital games illustrate two complementary strategies for transmitting craft knowledge through digital games. The former emphasises procedural learning via embodied interaction; the latter emphasises perceptual appreciation through altered scale and resolution. Both contribute to the preservation of craft heritage by reframing it within immersive, interactive environments, ensuring its relevance in a digital era.

4 Crafts: An Analogue and Virtual Game

4.1 Rationale

The design and implementation of Crafts, a board game created to educate and preserve traditional crafting techniques, is presented. The game simulates the challenges of craftsmanship through mechanics such as resource management, dice-based crafting checks, and tool upgrades. Players act as artisans, striving for wealth and reputation by creating intricate objects from raw materials. Thematic integration is a fundamental component, as the game's mechanics and card types directly reflect real-world crafting processes such as glass blowing, wood carving, and porcelain making. To enhance its educational value, each card features a QR code linking to informative content about the depicted techniques and tools. The game, accessible in physical and virtual formats, is an open-source project. Playtesting yielded positive outcomes, affirming the game's capacity to engage participants and stimulate their interest in traditional crafts, while highlighting areas for future enhancements in gameplay balance and strategic depth.

Crafts is a board game developed with the explicit aim of supporting the education and safeguarding of traditional crafts. The game was conceived in the context of the Horizon Europe project Craeft, which explores how digital technologies can sustain ICH. Responding to the needs of the project's valorisation pilot, and drawing inspiration from the designer's background in role-playing and strategic games, Crafts was designed to simulate artisanal processes in a form that is approachable and pedagogically grounded. Participants assume the roles of artisans specialising in glass blowing, clay and porcelain crafting, wood carving, and marble carving. They are tasked with acquiring raw materials, deploying specialised tools, and mitigating risks to produce crafted objects, which are subsequently offered for sale in pursuit of reputation and financial gain. Consequently, the game reconceptualises the artisan's workshop as a strategic environment where decisions, resources, and uncertainties converge. The game is distributed as an open-source print-and-play package on GitHub [60].

The *Crafts* game is available as follows:

- **GitHub** (print-and-play): https://github.com/giannistiv/Crafts-Board-Game
- **Steam** (Tabletop Simulator module): https://steamcommunity.com/workshop/filedetails/?id=3391572571
- **Craeft community portal article**: https://projects.madineurope.eu/craeft-community/crafts-an-analogue-and-virtual-board-game-dedicated-to-crafts/

The design embodies several key principles. First, regarding authenticity: all artwork and terminology are derived from the Mingei Online Platform (MOP) [61], thereby ensuring that the game's vocabulary accurately reflects real-world practices. Second, regarding educational integration, each card incorporates a QR code that links to supplementary information, enabling engaged players to transition smoothly from recreational activity to academic pursuit. Third, hybrid accessibility is achieved through the implementation in two formats: an analogue, print-and-play version, freely distributed under an open-source license, and a digital adaptation implemented in Tabletop Simulator [57] on the Steam platform [59]. This dual format expands access, facilitating physical interaction around a shared table and remote experimentation within a virtual environment.

The contribution of this work is threefold. Conceptually, it demonstrates how board games can become tools of cultural transmission, translating tacit artisanal knowledge into interactive systems without reducing it to mere abstraction. Methodologically, it provides a case study of design, implementation, and evaluation, documenting the translation of thematic research into mechanics of play. Practically, it offers an open-source game that can be adopted, adapted, and expanded by communities, educators, and researchers interested in the intersection of games and heritage. Its design, licensed under the MIT License, invites engagement and modification. An overview of the digital game is shown in Figure 12.

Figure 12. Overview of the *Crafts* board game, illustrating its analogue components and its virtual counterpart implemented on Tabletop Simulator.

The literature highlights three key observations. First, gamification offers proven methods for motivating engagement with CH, but often lacks tactile grounding. Second, educational board games provide a social and embodied medium for learning, though they are underutilised in heritage contexts. Third, existing work on games for crafts demonstrates feasibility but is fragmented and type-specific. This work builds on the intersection of these strands. By embedding authentic craft processes into the mechanics of a board game and providing analogue and virtual implementations, Crafts seeks to expand CH transmission, contributing to the scholarly conversation on gamification and learning, offering an open-source tool for educators, researchers, and communities engaged in safeguarding ICH.

4.2 Gaming Concept

The design rests on a conceptual framework that translates artisanal practices into the gameplay rationale. This framework clarifies the principles guiding design, the dimensions of 'simulation' considered, and the assumptions under which the game operates. Its purpose is not merely descriptive

but justificatory: it explains why particular mechanics were chosen, how they relate to real-world craftsmanship, and what forms of learning they are intended to elicit.

4.2.1 Gaming Dimensions

Four dimensions structure the translation of crafts into game systems: materials, tools, risks, and reputation.

1. **Materials rule.** In crafts, resources like wood, marble, or sand limit what can be created and at what cost. In the game, this is shown through Material Cards, which represent the scarcity and specificity of raw resources. The simulation is purposely simplified. Wood is shown as a single card type, rather than by species, but it keeps the main idea that materials must be chosen, gathered, and managed.
2. **Tools transform**. Just as artisans rely on specialised equipment, the game provides Tool Cards that confer advantages, increase efficiency, or reduce uncertainty. Tools in the game are in standard and upgraded versions, reflecting the progression from novice to master levels of proficiency.
3. **Uncertainty creeps**. Even skilled artisans fail due to imperfections in material, instability in technique, or unforeseen mishaps [62]. This is modelled through dice-based crafting checks: players must roll to determine success, with upgrades and strategies modulating outcomes. The inclusion of risk prevents the game from becoming deterministic, foregrounding the precarious balance artisans face between skill and chance.
4. **Reputation matters**. In real life, an artisan's status shapes opportunities for commissions and trust from clients. Within the game, reputation is abstracted into victory points, earned by successfully fulfilling Seller Cards. Thus, reputation serves as a reward and a measure of accomplishment.

These dimensions form the simulation skeleton. They do not replicate crafts in full fidelity but distil their core dynamics into a system of interlocking mechanics that are playable and instructive. These four dimensions and their translation into game mechanics are summarised in Table 1.

Table 1. Mapping real-world dynamics to game mechanics across four dimensions: materials, tools, risks, and reputation.

Dimension	Real-world Craft Dynamics	Game Mechanic Representation
Materials	Scarcity and specificity of resources	Material Cards
Tools	Material-specific equipment	Tool Cards
Risks	Uncertainty in production	Dice-randomised error occurrence.
Reputation	Recognition and status of artisans	Victory points from fulfilling Seller Cards

4.2.2 Analogue and Virtual Affordances

A second principle concerns the hybrid nature of the game. Traditional crafts are tactile, yet contemporary audiences increasingly inhabit digital environments. Designing *Crafts* in both analogue and virtual forms acknowledges this duality. The analogue version offers a tangible experience. Manipulating cards, rolling dice, and negotiating in person reflect the physical nature of craftwork. The virtual version, implemented in Tabletop Simulator, offers scalability and accessibility. It enables remote play, community testing, and

iterative modification. Both versions share identical mechanics, ensuring consistency of experience across formats. The framework, therefore, treats analogue and digital not as substitutes but as complementary channels, each extending the reach of the other.

4.2.3 Thematic Integration

A third principle is thematic authenticity. The game is not intended as an abstract engine-building exercise with superficial craft imagery. Rather, it derives terminology, imagery, and conceptual vocabulary directly from the MOP. This ensures that each card type corresponds to an actual practice, tool, or material. QR codes embedded on cards further extend this integration, linking the act of play to resources that provide historical and technical detail. The framework here distinguishes between primary and secondary integration. Primary integration regards mechanics mirroring artisanal processes, such as rolling dice to simulate the uncertainty of glassblowing or accidents in general. Secondary integration concerns supplementary features, such as QR codes, that provide contextual knowledge beyond immediate play. The intent is to allow primary integration to carry the weight of gameplay, while secondary integration offers depth for motivated players.

4.2.4 Assumptions and Design Principles

Four assumptions underpin our framework:

1. **Educational Potential**: Structured gameplay conveys factual knowledge and experiential qualities of craftsmanship; its uncertainties, dependencies, and rewards.
2. **Open Source**: Distributing the game freely under an MIT Licence supports adaptation, localisation, and community-driven improvement.
3. **Accessibility**: Analogue and virtual options increase inclusivity, accommodating diverse settings, i.e. classrooms, museums, and online communities.
4. **Risk**: An engaging game requires unpredictability to create tension, and strategy to reward planning.

These assumptions balance fidelity and playability. Too much realism risks overwhelming players with detail; too little risks trivialising the craft. The intent is to guide the translation of ethnographic and technical research into a system of rules that is accessible, enjoyable, and educational.

4.3 Game Design

The design and implementation followed a structured process, moving from conceptual vision to concrete mechanics and components. This section outlines the core game features, design principles, gameplay mechanics, and the dual analogue-virtual implementation.

4.3.1 Concept and Vision

The central idea is to place players in the role of artisans who create and sell crafted objects, pursuing wealth and reputation. Players begin with limited resources, acquiring tools, materials, and techniques during the game. The players confront opportunities and risks: high-value items offer prestige but require skill and luck, while simpler commissions provide steady income but little reputation.

This vision emerged from two sources. First, ethnographic research on traditional crafts conducted within the MOP provided the thematic backbone. Crafts such as glassblowing, clay and porcelain work, wood carving, and marble carving were selected for their cultural significance and their clear differentiation in terms of materials and techniques. Second, experience with role-playing and strategy board games informed the structural choices: resource management, risk-reward trade-offs, and incremental progression are familiar mechanisms in game design, but here they are reframed through a craft lens.

The design goal was to create a game that is educational and enjoyable. The effective integration of craft concepts facilitates educational objectives while engaging mechanics that are competitive, variable, and strategically significant, ensuring enjoyment. The table below shows the selected crafts, their materials, and representative tools.

Table 2. Craft domains included in the game, associated materials, and characteristic tools.

Craft	Materials	Example Tools
Glassblowing	Sand	Blowpipe
Porcelain/Clay	Kaolin, Clay	Kiln
Wood Carving	Wood	Chisels, Planes
Marble Carving	Marble	Mallets, Chisels

4.3.2 Game Mechanics

Gameplay in Crafts is organised around three primary phases:

Material Gathering	Players draw Material Cards from a deck or market row. These represent essential resources, such as sand, kaolin, clay, wood, or marble, that are prerequisites. The choice of which materials to pursue reflects strategic planning and opportunism.
Crafting	Players attempt to create objects by combining the necessary materials with appropriate tools or upgrades. Dice rolls determine success, with tools and upgrades offering modifiers. Failed rolls result in 'damaged goods' that can either be repaired in later turns or discarded. This mechanic captures the inherent risk of craft production: effort does not guarantee success.
Product Selling	Completed objects are sold to fulfil Seller Cards. These represent customer orders, specifying the required materials and the reward in gold and victory points. Seller Cards are divided into two categories: yellow cards for early-game, simpler commissions, and orange cards for late-game, complex and prestigious works.

The turn sequence repeats until a set number of rounds are completed or until a victory condition is reached. The player with the most victory points, representing accumulated reputation, is declared the winner.

This structure supports variation. Players can specialise in particular crafts, invest in upgrades, or pursue opportunistic strategies. The interaction of scarcity, risk, and reward ensures that no two games unfold in the same way.

4.3.3 Card Types and Functions

Four card types structure the game's economy: Material, Tool, Upgrade, and Seller Cards.

Material Cards denote raw resources, each linked to one or more crafts. For example, sand is integral to glass production, whereas marble is exclusively utilised in stone carving. Materials are intentionally simplified to maintain playability, yet their distinctiveness reflects real-world limitations.

Table 3. Gaming card types.

Tool Cards	Symbolise the specialised equipment artisans rely upon. Each craft features tools unique to its practice: a blowpipe for glass, chisels for marble, and kilns for porcelain. Tools are in standard and upgraded forms. Upgraded tools provide enhanced effects, such as reducing material requirements or granting rerolls, thereby modelling the efficiency gained through experience.
Upgrade Cards	Represent advanced techniques or broader expertise. They are divided into two categories: blue cards for techniques (e.g., kiln upgrades) and green cards for general expertise (e.g., master, apprentice). Upgrades support 'engine building,' where cumulative improvements yield accelerating benefits.
Seller Cards	Represent customer orders, driving the game objectives. They are graded by difficulty and reward, with simpler yellow cards facilitating early play and complex orange cards introducing high stakes in the late game.

The interaction between these card types is central. Materials enable crafting, tools increase success, upgrades build efficiency, and sellers provide goals and rewards. This interdependence reflects the circular economy of artisanal practice: resources flow into production, production generates reputation, and reputation fuels further opportunities. Examples of the card types are shown in Figure 13, each integrating authentic terminology and imagery.

Figure 13. Examples of the four card types in *Crafts*. Each integrates authentic terminology, imagery from the MOP, and QR codes linking to supplementary resources.

4.3.4 Risk and Uncertainty

Central to the design is the modelling of uncertainty through dice-based crafting checks. Each crafted object requires a roll against a target number. Tools and upgrades modify probabilities, but success is never guaranteed. A failed roll yields damaged goods, forcing players to choose between repairing the goods or abandoning them. This mechanic reflects two realities. First, artisanal production is inherently precarious: a single crack in porcelain or flaw in glass renders an object worthless. Second, artisans mitigate risk through investment in tools, techniques, and expertise. By making risk salient, the game conveys an insight: skill is necessary but not sufficient; fortune also plays a role.

4.3.5 Educational Integration

Education is embedded at multiple levels. The most direct is the inclusion of QR codes on all cards. When scanned, they link to the MOP, where detailed descriptions of materials, tools, and techniques are accessed. This bridges between gameplay and documentation, allowing players to explore at their own pace. Integration occurs at two levels. During play, the codes function as enrichments. Players may ignore them without detriment to the game. Outside play provides avenues for deeper learning, especially in classroom or museum contexts. Future iterations may integrate QR scanning into gameplay (e.g., bonuses for consulting sources). However, even in the current form, they serve as a conduit between playful and scholarly engagement.

In addition to QR linking, each card includes a short explanatory line describing the depicted material, tool, or technique. This supports learning even when QR scanning is unavailable (e.g., limited connectivity, time-constrained sessions) and helps bridge the gap between rule execution and heritage meaning.

4.3.6 Visual and Thematic Design

Authenticity is supported by the game's visual design. All artwork and illustrations are drawn directly from the MOP. This creates consistency between representation and reality: tools appear as they do in workshops, materials are rendered faithfully, and terminology is historically accurate. Beyond aesthetics, thematic design extends linguistically. Cards employ craft-specific vocabulary, exposing players to the terminology of each type of craft. By repeatedly encountering words such as 'kaolin,' 'kiln,' or 'blowpipe,' players begin to acquire a lexicon that connects play with practice.

4.4 Implementation

The game was implemented in two complementary formats.

- **Analogue**: Distributed as a print-and-play package on GitHub. Components include rulebooks, cards, player boards, and market boards. All files are freely available under an MIT Licence, encouraging casual play and community modification.
- **Virtual**: Developed on Tabletop Simulator and distributed via the Steam Workshop. This version replicates the analogue mechanics but provides additional benefits: remote multiplayer, ease of distribution, and accelerated playtesting. Virtual implementation facilitates scalability, as updates are rapidly deployed to a global audience.

To improve robustness of access, the project treats the GitHub repository as the canonical distribution point for the print-and-play package and as the long-term mirror for digital assets. Where third-party platforms (e.g., Steam Workshop) impose availability constraints, a mirrored release workflow ensures that the virtual implementation remains retrievable for project review and reuse.

The coexistence of analogue and virtual forms reflects the dual affordances of tactility and accessibility. Whereas the analogue game foregrounds material interaction, such as handling cards and rolling dice, the virtual game expands reach, allowing communities without physical access to engage in play.

Both versions are licensed under the MIT Licence, reinforcing the project's commitment to openness. This has two implications. First, it ensures accessibility: anyone can download, print, or play the game without cost. Second, it supports community engagement: educators and developers can adapt rules, translate components, or extend the system with new crafts. This aligns with the broader ethos of Horizon Europe projects, where sustainability depends on initial outputs and on supporting communities of practice.

4.5 Evaluation and playtesting

Playtesting was conducted with three participants, including two individuals with no prior knowledge of traditional crafts and one with limited familiarity. Feedback focused on accessibility, thematic engagement, perceived educational value, and gameplay balance. Overall experience ratings were positive (two participants: 4/5; one participant: 3/5), indicating that the ruleset is approachable while still providing meaningful decisions. Ratings of the thematic aspect were also positive, suggesting that the mapping between craft processes and game mechanics is legible to non-experts. The QR-code feature received mixed feedback (two participants rated it 5/5, one rated it 3/5), implying that the link-out mechanism is valuable but should be more tightly integrated into play to ensure consistent uptake.

Category	Positive observations	Challenges
Rule clarity	Easy to learn; no difficulties reported	None reported
Thematic engagement	Link between mechanics and crafts	None reported
Educational impact	Increased interest in crafts after play	QR codes are underused by some players
Gameplay balance	Exciting early strategies	Late-game feels restricted; dependence on dice outcomes

4.6 Conclusions

The evaluation of Crafts highlights its immediate contributions and its potential trajectories. This work has implications for education, CH, and policy. At the same time, several avenues for refinement and extension emerge from the findings.

One implication lies in the incorporation of Crafts into formal and informal educational settings. In classrooms, the game could complement history or art curricula by providing experiential access to craft

practices. In museums, it could serve as an interactive exhibit, enabling visitors to engage actively with cultural knowledge. For apprenticeships, it could act as an introductory resource, offering novices a playful way to familiarise themselves with terminology, tools, and risks before engaging in physical practice. To realise this potential, further adaptation may be required. For instance, educators can design lesson plans around the game, linking QR codes to curated resources or discussion prompts. Museums could deploy the digital version on interactive tables, embedding the game into exhibition spaces. Such integrations would require careful collaboration between designers, educators, and curators to align gameplay with pedagogical objectives.

A second trajectory involves using emerging technologies to improve the hybrid model. Augmented reality (AR) could allow players to visualise crafted objects in three dimensions, overlaying virtual artefacts onto the physical cards. Virtual reality (VR) could offer immersive extensions where players step into simulated workshops, guided by the same mechanics but enriched by spatial interaction. Adaptive difficulty systems could personalise gameplay, adjusting probabilities or rewards based on player experience. While technology is not necessary for the core experience, it expands reach to new audiences, particularly younger ones. The challenge is to integrate these features without sacrificing the clarity and accessibility that characterise the board game format.

The game, as currently implemented, covers five craft domains, while the framework is extensible to additional craft traditions. New decks could be developed for textiles, metalwork, leathercraft, or regional traditions. Community-driven expansion is particularly promising: local groups could adapt the system to their own heritage, producing culturally specific modules while preserving compatibility with the base rules. Such scalability would enrich the game and promote cultural resilience. By enabling communities to represent themselves through play, Crafts could become a platform for the documentation and transmission of diverse traditions.

This work has policy implications. European frameworks emphasise the safeguarding of ICH as a pillar of cultural sustainability. Open-source, educational tools such as *Crafts* align with this agenda by offering resources that are accessible, adaptable, and capable of evolution. The MIT Licence enables the game to be maintained by communities.

Future development will concentrate on three primary areas. Firstly, iterative refinement will address issues identified during playtesting, such as late-game strategic considerations and the influence of chance. Secondly, expanded evaluation will involve larger and more diverse participant groups to assess the educational impact more robustly. Thirdly, the integration of QR codes into core mechanics will make the educational value of linked resources realised within the gameplay experience.

Concrete next steps derived from playtesting include: (i) adding mid-game options that expand crafting pathways as difficulty scales, preventing late-game narrowing of viable actions; (ii) introducing limited mechanics that mitigate extreme luck (e.g., upgrades that guarantee a minimum dice outcome or provide controlled re-rolls), while preserving uncertainty as a representation of real workmanship risk; (iii) rebalancing tools and upgrades identified as disproportionately strong or weak through iterative tuning; and (iv) integrating QR codes into gameplay via optional in-game bonuses or abilities unlocked by consulting linked documentation, thereby turning educational engagement into a meaningful player choice rather than a parallel activity.

5 Physical Toys and Games

5.1 Communities of 3D printable designs

Course url: https://www.craeft.eu/elearning/course/view.php?id=154

This section reports a desk research activity that mapped online communities and repositories where makers share 3D-printable designs relevant to craft-related educational toys and games. The goal was (i) to identify designs that can be fabricated with common desktop FDM printers and used in informal learning settings, and (ii) to understand the "distribution ecology" (documentation norms, remix practices, and licensing patterns) that would affect reuse, adaptation, and dissemination of CRAEFT outcomes.

Desk research protocol (scope and selection criteria). We conducted a targeted scan of major 3D-printing repositories and community platforms, using craft-related keywords (e.g., *loom, weaving, bracelet, bead loom, pottery wheel, pottery tools, clay stamp*) and browsing relevant categories/collections. Candidate designs were shortlisted when they:

- align with craft learning goals (procedural thinking, material handling, patterning, sequencing);
- can be printed and assembled with modest resources;
- offer sufficiently clear documentation (photos, instructions, community comments); and
- have licensing/terms that permit educational use (to be verified per listing at time of reuse).

Platform landscape (summary). Platforms such as **Thingiverse**, **MyMiniFactory**, **Cults3D**, and **Printables** act as hubs for distributing designs and sharing modifications. They differ in curation and access model (fully open vs mixed marketplace), which affects the reliability of printability claims and the effort needed to turn a design into "classroom-ready" educational material. Detailed platform profiles and the full catalogue of shortlisted designs (including links and representative images) are provided in **Annex D** to keep the main deliverable concise and traceable.

5.1.1 Purpose and motivation (desk research)

This section reports a desk research activity carried out to map online communities that share 3D-printable designs relevant to craft-related educational toys and games. The motivation is twofold: (i) to identify accessible, low-cost, and reproducible physical artefacts that can support informal craft education; and (ii) to understand dissemination and valorisation pathways for CRAEFT outputs, by situating our prototypes within the wider ecosystem of maker communities and design repositories.

5.1.2 Desk research protocol (sources and criteria)

We conducted a targeted search of major 3D-printing design repositories and community platforms, focusing on designs suitable for printing with common desktop FDM printers and safe for use in educational or family settings. Searches employed craft-related keywords (e.g., loom, weaving, pottery, mould, casting, chess) and were complemented by browsing relevant categories and user collections.

Candidate designs were shortlisted based on: (a) relevance to craft learning objectives; (b) ease of fabrication and assembly; (c) clarity of documentation; and (d) licensing terms allowing educational reuse. For each shortlisted design, we recorded the repository link, design type, intended use, fabrication notes, and the educational rationale.

5.1.3 Outputs and how to read them

The desk research resulted in (i) a summary of the most relevant communities and their typical licensing/quality characteristics, and (ii) a catalogue of representative craft-related toys and accessories that can be 3D printed. To keep the main deliverable focused on CRAEFT's approach and outcomes, the detailed catalogue entries (including links and figure set) are provided in **Annex X**, while this section summarises the key findings and highlights the designs that were taken forward as prototypes or use cases.

5.1.4 Printable looms use cases

The desk research identified several small-scale loom concepts that are well-suited to informal craft education because they externalise core weaving ideas (warp/weft separation, tension, pattern repetition) tangibly. We observed three recurring design families:

Mini looms: handheld frames with simple heddle/shuttle/beater concepts.

Loop looms: E.g., potholder looms: which simplify weaving into a robust, stepwise activity suitable for novices.

Bracelet looms: Rubber-band and bead looms: emphasise patterning and fine motor coordination.

Representative examples and sources are provided in Annex D (see Figure 44, Figure 45, Figure 46, and Figure 47).

5.1.5 Printable pottery toys

The desk research also surfaced a cluster of pottery-related 3D-printable designs that can support introductory learning in clay work: compact pottery wheels, printable pottery tools, and rolling stamps for texture/pattern transfer. These designs are useful as educational artefacts because they let learners explore: (i) tool–material interaction (pressure, friction, surface finish), (ii) patterning and repeatability, and (iii) the translation of a digital pattern into a physical imprint. Representative examples and sources are provided in Annex D (see Figure 48, Figure 49, and Figure 50).

5.2 Craeft Use Cases

5.2.1 Looms

To move from "findings" to a reproducible educational asset, we **implemented and validated** one shortlisted weaving design as a pilot. During validation, we found that (i) inexperienced 3D-printing users

benefit from explicit print/material guidance; (ii) the loom structure may deform under strong tension; and (iii) thin pins can fail under pressure. We addressed these issues by **mounting the loom on a wooden base** (improving stability and reducing warping) and **reprinting with higher infill** to improve robustness. After these adjustments, we produced the first finished item and recorded the full process so it can be converted into step-by-step educational material. The adapted configuration and outcome are shown in Figure 14.

Figure 14. Example of the application of the potholder design.

Demonstration video: https://youtu.be/PkuuYQROuYI

5.2.1 3D-Printed Moulds for casting

Casting and moulding are found in everyday life: chocolate is often cast into moulds, while dough can be pressed into forms.

Casting vs Pressing

Casting is how chocolate bars are made: melted chocolate is poured into moulds and allowed to harden.

Pressing resembles how dough is pushed into cookie cutters or pie forms: the soft solid takes shape through pressure.

In our demonstrator, non-edible materials are proposed, namely soap, wax, plasticine, and clay.

The use of 3D-printed moulds inspired by chess pieces was used to create a tutorial and activity. Its theme motivates user to create their own soap chess set at home. The process requires only everyday tools, a few supplies, and patience.

Casting vs Pressing: What's the Difference?

- Casting: The material is melted into a liquid state, poured into the mould, and then allowed to solidify. This ensures that fine details are captured. In this tutorial, soap and candle wax are used.
- Moulding (Impression Moulding): A soft but solid material is pressed into the mould cavity by hand or pressure. Because the material is not fluid, it often fails to fill fine details or may deform when removed. In this tutorial, plasticine and clay are used.

Insight: Casting is best for precise and detailed results. Pressing is easier, but less accurate.

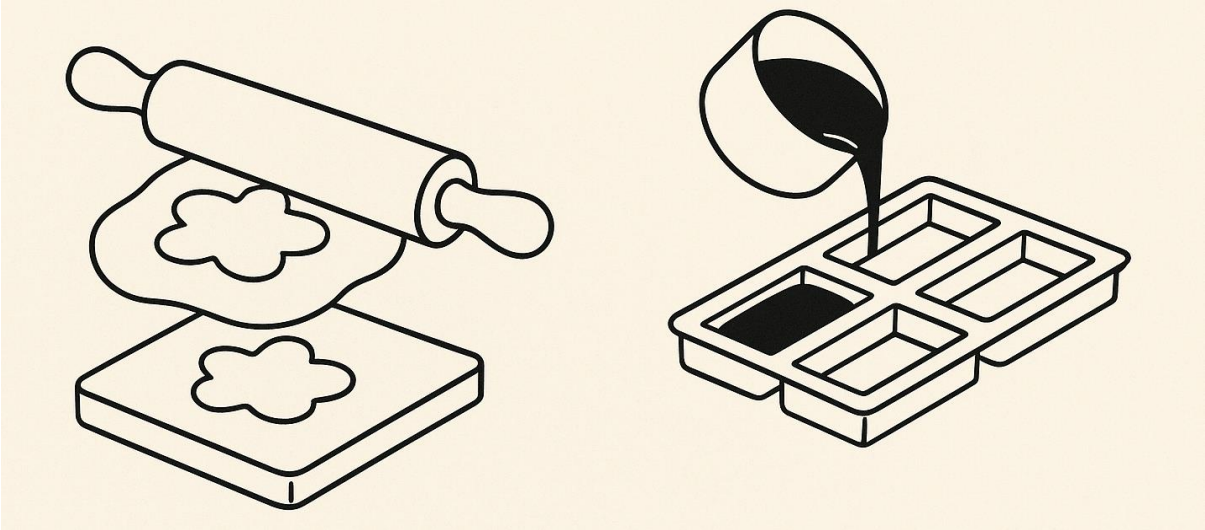


Figure 15. Mould casting

5.2.2 Kitchen Casting Game: Make, Pop, Play

This is a hands-on making game you can do at home, using simple kitchen tools and ready-made moulds. The goal is the fun of transforming everyday materials into little objects: mix, melt, pour, wait, then *pop!* your creations out of the mould. You can experiment with soap or candle wax, try colours, combine layers, and see how small changes affect the results. Some pieces come out crisp and perfect; others are wonky in a charming way—and that's part of the game.

Think of it as a creative challenge rather than a craft recipe: how clean can you get the details, how smooth can you make the surface, and what surprises can you design into the next pour? The shapes can become game tokens, tiny figures, counters, or just a collection of handmade 'mini treasures'—whatever your family wants them to be.

Quick safety note: if you use hot wax or melted soap, grown-up supervision is essential.

Materials & Tools

1. 3D-printed chess moulds
2. Soap base (100 g per batch)
3. Kitchen scale
4. Knife (to cut soap base)
5. Coffee pot or small saucepan (to melt)
6. Wooden chopstick or spoon (for stirring)
7. Gas lighter (optional)
8. Rubber bands (to secure moulds)
9. Oil (for unmoulding)
10. Cotton swabs (to apply oil)
11. Alcohol spray (to prevent bubbles)
12. Soap colouring (1 drop per 100 g)
13. Scissors or knife (for trimming excess)

Table 4. Kitchen casting instructions

Step 1

Prepare the moulds with oil for easy release.

Apply a thin layer of oil inside the moulds using cotton swabs. This helps the soap pieces release smoothly once hardened.

Step 2

Melt the soap base carefully on low heat.

Cut 100 g of soap base and place it in a coffee pot. Heat gently over low flame, stirring constantly. Avoid high heat, which burns the soap and produces an unpleasant smell.

Step 3

Add colour: one drop per 100 g of soap.

Once melted, add 1 drop of soap colouring per 100 g batch. Stir until the colour is evenly distributed.

Step 4

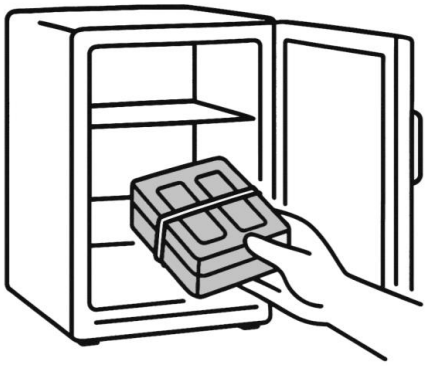
Cast the soap into tightly sealed moulds.

Pour the melted soap into the prepared moulds. Secure the mould halves with rubber bands to prevent leaks. Lightly tap the moulds on the table to release trapped air bubbles. Spray alcohol on the surface to further minimise bubbles.

Step 5

Solidify.

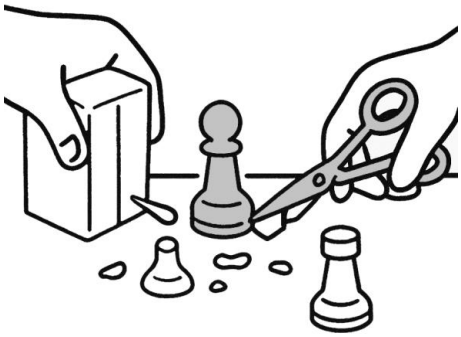
Allow the soap to set. Wait until fully hardened.



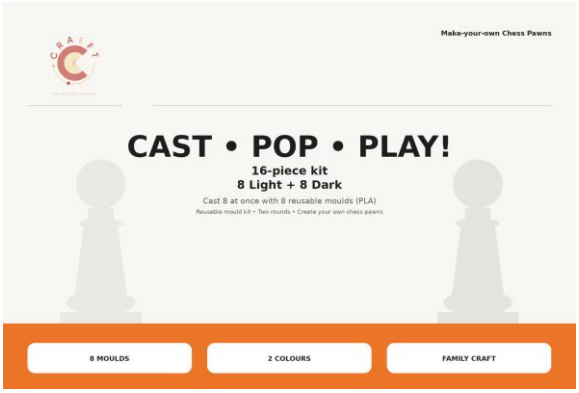
Step 6

Unmoulding the finished soap chess pieces.

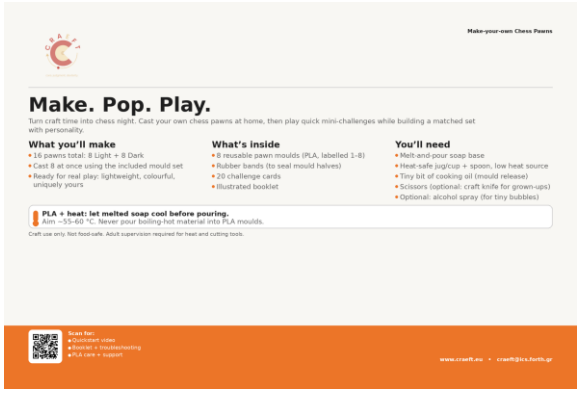
Carefully remove the hardened soap pieces from the moulds. Trim away any excess material along the seams using scissors or a knife.



Box



Front



Back

Figure 16. Box design

Lab Manual

Quickstart Video: https://youtu.be/jkXT8wFxmcw

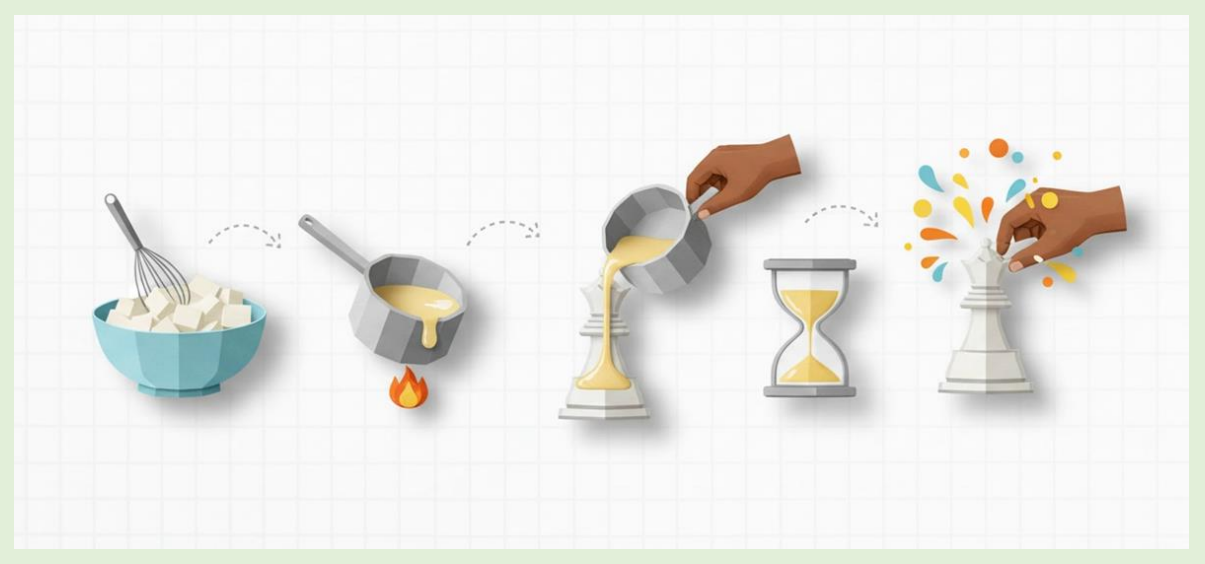


Table 5. Lab Manual

The Kitchen Casting Game

Transform simple soap into a custom chess set.
A hands-on guide to making, popping, and playing.

This tutorial is a creative challenge, not just a recipe. The goal is the fun of **transforming everyday materials** into tangible treasures. Mix, melt, pour, wait, and pop! Some pieces will be perfect, others **charmingly wonky—and that's part of the game.**

Master the Fundamental Choice: Casting vs. Pressing

Before we begin, let's understand our technique. The quality of your final pieces depends on choosing the right method.

Casting

A material is melted into a liquid, poured into a mould, and allowed to solidify. This captures fine details with precision.

Think of how melted chocolate is used to make detailed figurines. This is our method.

Pressing (Impression Moulding)

A soft but solid material is pressed into a mould. This is simpler but often fails to fill small details and can deform.

Think of pressing cookie dough into a cutter.

Key Insight: We use casting for the crisp, detailed results needed for our chess pieces.

The Two Paths: A Visual Guide

PRESSING

A soft solid is shaped with pressure.
Good for simple forms.

CASTING

A liquid is poured to fill every detail.
Ideal for complex shapes.

Assemble Your Maker's Toolkit

Core Materials

- 3D-printed chess moulds
- Soap base (100 g per batch)
- Soap colouring (1 drop per 100 g)
- Oil (for unmoulding)
- Alcohol spray (to prevent bubbles)

Essential Tools

- Kitchen scale
- Knife (to cut soap base)
- Coffee pot or small saucepan
- Wooden chopstick or spoon (for stirring)
- Cotton swabs (to apply oil)
- Rubber bands (to secure moulds)
- Scissors or knife (for trimming excess)

Step 1: Prepare the Moulds for a Perfect Release

This first step is crucial for ensuring your finished pieces come out clean and whole.

1. Apply a thin, even layer of oil to the inside surfaces of the moulds using a cotton swab.
2. Securely fasten the mould halves together with rubber bands. They must be tight to prevent leaks.

A Quick Safety Briefing

The next step involves heat. When using a stove to melt soap base or wax, adult supervision is essential. Please ensure a clear, washable workspace.

Step 2 & 3: The Alchemist's Art of Melting and Coloring

Part 1: Melt the Base

- Weigh and cut 100 g of soap base into small pieces.
- Place in a coffee pot or small saucepan.
- Heat *gently* over a low flame, stirring constantly. Avoid high heat, which will burn the soap. Patience is key.

Part 2: Add the Color

- Once fully melted, add exactly one drop of soap colouring per 100 g batch.
- Stir until the color is evenly distributed throughout the liquid.

Step 4: Cast the Liquid Soap and Banish Bubbles

Work carefully but quickly while the soap is liquid.

Pour: Slowly decant the liquid soap into the prepared, sealed moulds.

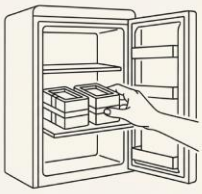
Tap: Immediately and lightly tap the moulds on the table for a few seconds to help release any large, trapped air bubbles.

Spray: Lightly mist the surface of the poured soap with alcohol spray. This breaks the surface tension and eliminates the final microbubbles, ensuring a smooth finish.

Step 5: The Test of Patience—Let It Solidify

Allow the moulds to sit undisturbed until the soap has completely hardened. This can take some time, so be patient.

Pro-Tip:To accelerate the curing process, you can optionally place the sealed moulds in a freezer.



Step 6: Reveal Your Treasure and Refine the Details

Once the soap is fully solid, it's time for the reveal.

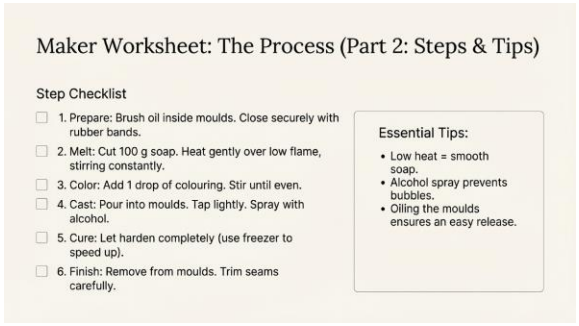
Demould: Carefully remove the rubber bands and separate the mould halves halves to release your new chess piece.

Trim: Use a small knife or scissors to carefully trim away any excess material or 'residue' along the seam lines where the mould halves met.

Behold Your Handcrafted Collection

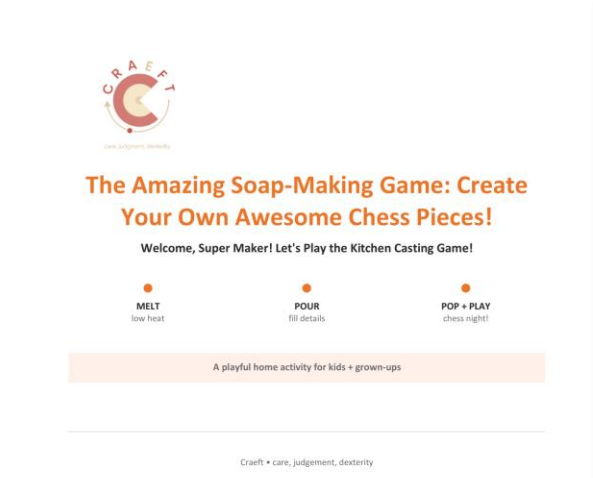
With practice, your pieces will emerge clean and detailed. But remember, the goal is the fun of the process. Your collection of 'mini treasures' can be game tokens, tiny figures, or simply proof of your creative quest.

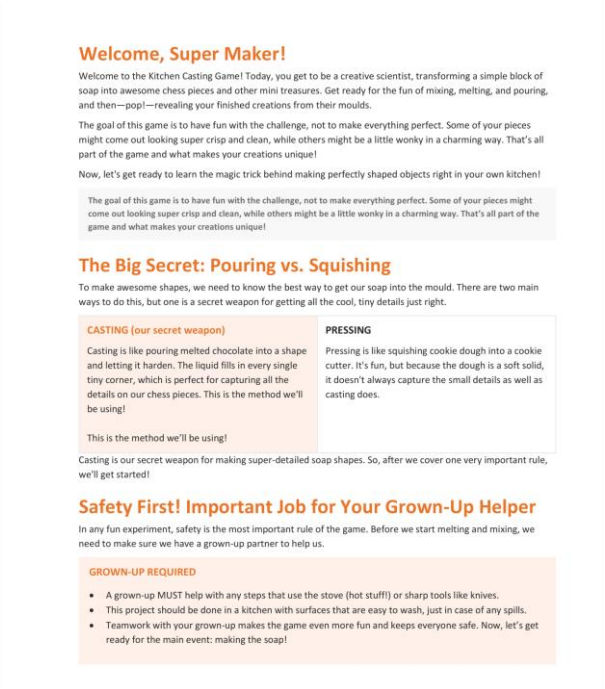
Want a new challenge? Try the same process with candle wax to create a full candle chessboard.



Leaflet for Children [Craeft_Kitchen_Casting_Game.pdf]

Table 6. Leaflet for children





Your Maker Toolkit: Gathering Your Supplies

It's time to gather the tools and ingredients for our cool science experiment! Having everything ready before you start makes the whole process smooth, easy, and even more fun. Here's what you'll need:

The Moulds: 3D-printed chess moulds
The Magic Stuff: Soap base (about 100g, which is a small block)
For Measuring: A kitchen scale
For Cutting: A knife (a grown-up's tool!)
For Melting: A small coffee pot or saucepan
For Stirring: A wooden chopstick or spoon

To Stop Leaks: Rubber bands
For a Smooth Release: A little bit of oil and some cotton swabs
The Bubble Zapper: An alcohol spray bottle
To Make it Colourful: Soap colouring (just one drop is enough!)
To Make it Smell Amazing: Aromatic oil or soap scent (a few drops)
For a Final Tidy-Up: Scissors or a small knife (another grown-up tool!)

Got everything? Awesome! Let's start making some magic.

The Secret Recipe: 6 Steps to Your Soap Masterpiece!

You're all set! Now it's time to follow the secret recipe for turning liquid soap into solid treasures. Follow these six simple steps to create your masterpiece.

Get the Moulds Ready!

Use a cotton swab to wipe a little bit of oil on the inside of your moulds. This makes them slippery, so your finished soap pieces can pop out easily later! Then, close the moulds and wrap rubber bands around them tightly so no soap leaks out.

Melt the Soap!

Have your grown-up helper cut up the soap base and put it in the pot. They need to heat it on the stove using low heat and stir it gently until it's all melted liquid. Heating it slowly is key to keeping the soap from burning!

Add Colour and Scent!

Once the soap is melted, add just ONE drop of soap colouring and a few drops of your favourite scent. Stir it with your wooden stick until everything is mixed in perfectly.

Pour the Magic Potion!

Carefully pour the coloured liquid soap into your prepared moulds. Once they are full, gently tap the moulds on the table to help any big air bubbles escape. Then, give the top a quick spray with the alcohol to zap away any tiny bubbles for a super smooth finish.

Wait for it to Harden!

Now it's time to be patient! Let the moulds sit until the soap inside gets completely hard and solid. If you want to speed things up, you can ask your grown-up to put the moulds in the freezer.

Reveal Your Creation!

This is the best part! Carefully open the moulds and take out your brand-new soap chess pieces. Ask your grown-up to help you use scissors or a knife to carefully trim off any extra bits of soap along the edges.

You did it! Now let's see what amazing pieces you've created.

You're a Pro! Key Learnings for Your Next Creation

Congratulations! You've just learned the secret skills of a real maker. You now know how to turn a digital design into a real object you can hold. Here are a few pro tips to remember for your next project:

Patience is Power: Using low heat when melting the soap and waiting for it to harden properly is the secret to getting it just right.
The Details Matter: Using oil in the moulds helps your pieces come out perfectly, and the alcohol spray is the best trick for zapping bubbles to get a perfectly smooth surface.
You Don't Need Fancy Tools: You can make amazing things right in your kitchen with everyday stuff!

You can use your new creations as game tokens, tiny figures for adventures, or just a cool collection of handmade treasures. Now that you're a pro, try experimenting with different colours or even making candle wax pieces next (with your grown-up's help, of course!). Happy making!

Maker Worksheet: Soap Chess Pieces with 3D-Printed Moulds

Materials

1. 3D-printed chess moulds
2. Soap base (100 g per batch)
3. Kitchen scale
4. Knife
5. Coffee pot or small saucepan
6. Wooden stick or spoon
7. Rubber bands

8. Oil + cotton swabs
9. Alcohol spray
10. Soap colouring (1 drop per 100 g)
11. Scissors/knife (for trimming)
12. Freezer (optional)

Step Checklist

Table 7. Kitchen casting – step checklist

1. Prepare the moulds	
Brush oil inside the moulds with a cotton swab.	
Close moulds securely with rubber bands.	
2. Melt the soap base	
Cut 100 g of soap.	
Heat gently over a low flame.	
Stir constantly (don't boil).	
3. Add colour	
Add exactly 1 drop of colouring per 100 g.	
Stir until even.	
4. Cast the soap	
Pour melted soap into moulds.	
Tap moulds lightly on the table.	
Spray alcohol to remove bubbles.	
4. Cure	
Let the soap partially set.	
Store the moulds until they harden.	
6. Unmould & finish	
Remove hardened pieces carefully.	

Trim seams with scissors/knife.	

Tips

- Low heat = smooth soap.
- Alcohol spray prevents bubbles.
- Oiling the moulds helps to release easily.
- Freezer speeds curing.

5.2.3 Chess Use Case

Rationale

1. **Case Selection**. The choice of chess was deliberate: it is a game with near-universal recognition, rules already familiar to most audiences, and a market that spans digital and physical domains. We base our selection on proven popularity and cultural visibility to target broad publics and better disseminate our relevance to craft innovation.
2. A **manufacturing process**.
    a. Material and process
    b. Technology in the service
3. **Better understanding**. Linking with the semantic and simulation framework. Learners see the practical steps associated with how the action is formally defined and related to broader semantic and physics concepts. This makes it interoperable with heritage vocabularies (like AAT) and educational standards.

Chess was chosen as the demonstrator for Craeft due to its widespread cultural familiarity, global popularity, and significant market presence. It serves as a suitable basis for a handcrafted demonstrator object, given its cultural prestige and its unique presence in both digital and physical forms. The rules of chess are widely recognised, ensuring accessibility for diverse audiences. Its widespread appeal across schools, clubs, online platforms, and professional tournaments makes it a perfect bridge between digital fabrication and traditional craftsmanship.

Co-creation with an Expert

The selection of chess as a demonstrator within Craeft emerged through a structured co-creation activity with stakeholder Sibel Aksu Güngör. Dr Güngör holds an MBA in Art Management and a PhD in Anthropology, and her research focuses on the practice and culture of collecting. As a lecturer in Psychological and Cognitive Anthropology and the founder of PUHU Research and Consultancy, she brings expertise in the interplay between cognitive processes and social issues, as well as in curatorial and cultural innovation.

The activity was centred on exploring how diverse craft techniques could be channelled into the creation of chess sets. This framing served two purposes: to introduce traditional crafts to new audiences in a familiar form, and to demonstrate their adaptability to contemporary contexts. Through discussion and joint brainstorming, chess was identified as the optimal candidate.

Several considerations guided this decision. Universality was key: chess is recognised across cultures, ensuring accessibility and immediate familiarity. Its well-studied nature meant that Craeft did not need to enter into foundational research in game theory or test basic playability, allowing the focus to remain on craft techniques. Importantly, although originating in India, chess has deep roots in European history, linking naturally to contextualisation and historical narratives in European art and culture.

From a craft perspective, chess is uniquely versatile. Both the board and the pieces can be realised through practically all Representative Craft Interfaces (RCIs), either individually or in combination. Variations in material and technique allow for rich exploration. For example, different crafts can be applied to distinguish the colours of pieces, or to combine contrasting approaches within a single chessboard.

In this sense, the co-creation session not only justified the choice of chess but also framed it as a flexible platform for demonstrating the project's central aim: to showcase the resilience and adaptability of traditional crafts when situated in a modern, globally recognised medium.

Market Analysis

A detailed version of this analysis is provided in Annex B.

Chess resonates across digital and physical domains and has witnessed a strong resurgence in recent years. The chess set market serves as a material indicator of the game's popularity. Millions of sets are sold annually across traditional and digital retail channels, with values estimated in the billions. The range is striking: from inexpensive plastic boards designed for schools and casual players, to finely crafted wooden and luxury sets intended as collector's items or decorative pieces.

The enduring institutional legacy of chess is upheld by elite tournaments sanctioned by the International Chess Federation (FIDE). Online platforms, such as Chess.com (with 200 million members) and Lichess, attract millions of players daily. In contrast, millions of physical sets are sold annually, ranging from inexpensive educational kits to luxury collector's editions. Chess has transformed into both an e-sport and a popular form of live entertainment. This is evident in events like Twitch's PogChamps [33]. The reach of chess has been further expanded by social media, where influencers attract millions of followers through streaming platforms [29]. Additionally, popular culture, such as 'The Queen's Gambit' [ISAN 0000-0007-70BA], has boosted its visibility, leading to a documented increase in registrations, chessboard sales, and online search traffic (Variety, 2020; The Guardian, 2020).

Chess is a cultural phenomenon that bridges traditional play and digital spectacle, serving as both a conventional cultural object and a contemporary global medium. This aligns with Craeft's goal of linking past practices with present technologies. For this deliverable, chess offered a framework for experimentation with 3D-printed moulds, creativity, and marketability, making it an ideal choice for a demonstrator within Craeft. Its universal recognition, contemporary resurgence, and strong market presence ensure its relevance for various audiences and evaluators.

Production

Two types of processes were tested with the chess-piece moulds: casting, where the material is melted and poured (such as soap or wax), and pressing, where a malleable material is forced into the mould

without melting (such as plasticine or clay). The contrast revealed why casting is better suited for detailed and consistent results.

1. Moulding: a malleable material is forced and deformed into a mould. Flow and solidification are applied to liquids. Materials: Plasticine, Clay.
2. Casting: the material is melted and poured. Force and pressure are applied to soft solids.

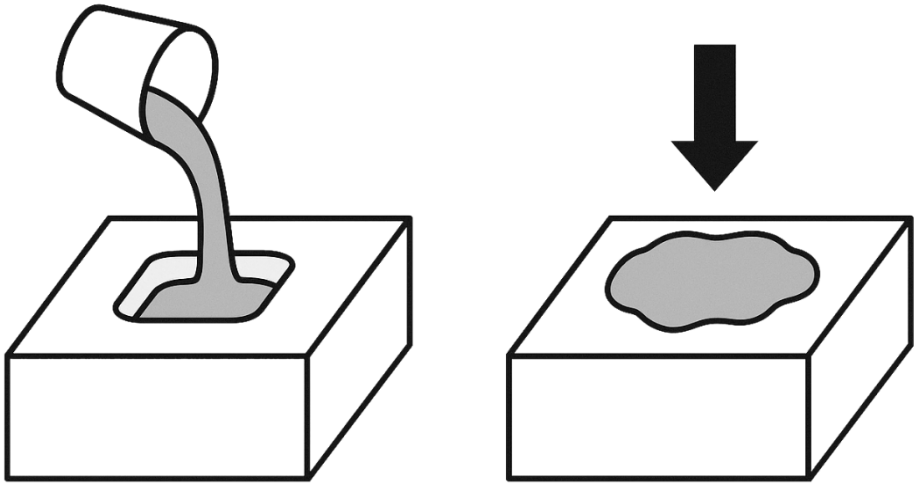


Figure 17. Casting (left) and Moulding (right).

Table 8. Comparison of moulding and casting.

	Practitioner	State	Time	Quality
Moulding	Pushes material	Soft	Fast	Coarse
Casting	Pours liquid	Liquid	Slow	Fine

Table 9. Temporal layout.

	Step 1	Step 2	Step 3
Moulding	hydrate	push	dry
Casting	melt	pour	solidify

Table 10. Semantic Framing (AAT).

Process	Moulding (nipping)	Casting
Control	filling	pouring
Material	clay, plasticine (moulding material)	wax, soap

Actions	pressing and, sometimes, drying	melting and solidification
Cause	force, pressure	force, heat
Tools	pressing machines	melting pots, casting moulds

Making and Testing

Objectives

- Explore the usability of 3D-printed moulds for small-scale casting using everyday tools.
- Test multiple materials to identify their challenges and possibilities.
- A repeatable process transforming designs into objects.

Materials and Methods

A detailed report of this experimentation is provided in Annex D.

A series of moulds based on chess pieces was designed digitally in the Design Studio and fabricated using 3D printing. These moulds were then used in moulding and casting experiments with various materials: plasticine, clay, soap, and candle wax. The activity relied on ordinary domestic equipment rather than specialised workshop tools, reinforcing the project's focus on accessibility. Iterative trials evaluated for technical feasibility, creative potential, and educational value.

Moulding experiments with plasteline and clay. The original approach was to place the moulding material in each mould half separately and then join them together. However, this turned out to be time-consuming and technically unstable. The material could not remain homogeneous at the joint line, resulting in unsatisfactory outcomes.

We advance to evaluate casting with wax and soap. The treatment process followed a sequence: preparing and oiling the moulds → carefully melting the material at controlled temperatures → adding colour in precise ratios → casting into sealed moulds → cooling or freezing to accelerate curing → and finally, unmoulding and trimming. Iterative trials highlighted the importance of temperature control, mould sealing, and bubble prevention techniques.

Table 11. Comparison of materials.

Plasticine	Too malleable, resulting in distorted shapes upon unmoulding.
Clay	Unstable at the seam line when joining halves, producing unsatisfactory results.
Soap	Highly successful after adjustments. Oiling, alcohol spray, and tapping improved outcomes. A full soap chess set was produced, featuring detailed and consistent pieces.
Wax	Early trials suggest promising results, raising the possibility of a complete candle chessboard.

The contrast reveals that casting is better suited for detailed and consistent results. Moulding is quicker but imperfect. Through trial and error, the soap-based experiment demonstrated that 3D-printed moulds can reliably produce intricate and durable artefacts using only household resources.

Comparable processes can be found in everyday life: chocolate is often *cast* into moulds, while dough can be *pressed* into forms. These familiar examples illustrate the distinction between casting and moulding, also known as pressing. In our demonstrator, however, only non-edible materials such as soap, wax, plasticine, and clay were used to avoid any safety risks.

Everyday Analogies: Casting vs Pressing

- **Casting** is familiar from how chocolate bars or figurines are made: melted chocolate is poured into moulds and allowed to harden.
- **Pressing** resembles how dough is pushed into cookie cutters or pie forms: the soft solid takes shape through pressure.

These food examples help illustrate the *difference* between casting and pressing.

Note: We did not use edible materials. Only soap, wax, plasticine, and clay were tested to ensure safety in a public context.

Reflections

Physics: When liquid material is poured into a mould, air may be trapped within cavities. These air pockets rise through the liquid as bubbles remain adhered to the mould walls, leaving small voids or pockmarks once the cast solidifies. For the reproduction of fine details, bubbles are a fundamental challenge because they disrupt material continuity and compromise surface quality.

The appearance of bubbles is governed by surface tension, the cohesive force that holds liquid molecules together at their boundary. Surface tension resists the rupture of bubbles, allowing them to persist longer than desirable. In confined mould spaces, the geometry may further hinder the escape of air, especially in narrow recesses.

Craft practice and industrial casting share similar solutions to this problem. One simple method is to tap or gently vibrate the mould after pouring, encouraging bubbles to rise to the surface where they can disperse. A more targeted intervention is the application of an alcohol spray to the liquid's surface. The alcohol acts as a surfactant, temporarily lowering surface tension and enabling bubbles to burst rapidly. Because alcohol evaporates quickly, it leaves no residue in the finished cast.

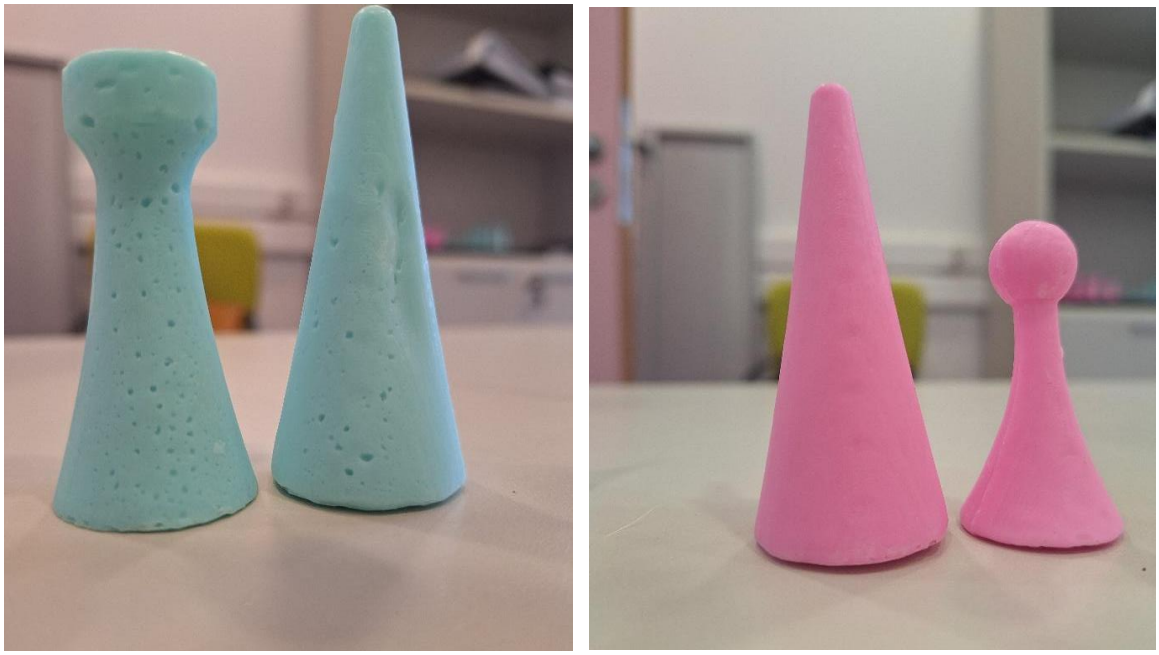


Figure 18. Left: the effect of bubbles. Right: Improved pieces manufactured in the colour and scent of choice.

In this sense, the management of bubbles is not only a matter of convenience but also physical: it demonstrates how molecular forces, invisible to the eye, influence the fidelity of a cast. The small act of spraying alcohol embodies a practical negotiation between material behaviour and desired outcome, showing how traditional knowledge and scientific principle converge in the casting process.

Design Interpretation

Mould design is governed by geometry. A mould must not only capture the desired shape of an object but also allow that object to be released once the material has hardened. This release condition is straightforward for simple shapes, but becomes more complex as soon as the object includes undercuts, which are features that curve back beneath the parting line (cusps). An undercut locks the object in place, preventing it from being withdrawn along a single direction.

The most common moulds are two-part moulds, divided into halves along a single plane. These work effectively for geometries that can be separated cleanly, such as simple blocks, cylinders, or forms with tapered sides. However, when undercuts are present, a two-part mould becomes insufficient. Attempts to extract the object often result in breakage of the cast or damage to the mould itself.

The solution is to increase the number of mould parts. By dividing the mould into four sections, each part can be withdrawn along a different axis. This multi-directional separation resolves the undercut problem, allowing even intricate geometries to be released intact. In practice, this means that four-part moulds expand the range of objects that can be reproduced, since they accommodate shapes that would otherwise be impossible to extract. This principle aligns with broader theories in manufacturing and topology. From a manufacturing perspective, mould-parting strategies are dictated by the geometry of the object to ensure a feasible release path. From a topological standpoint, an undercut is an obstruction

in the release trajectory, which can only be resolved by introducing additional mould divisions. Thus, the move from two to four parts is not arbitrary; it is a geometric necessity dictated by the object's form.

Figure 19. Unmoulding the finished soap chess pieces from two (left) and four-piece moulds (right).

In conclusion, the transition from two-part to four-part moulds is not just a technical adjustment but a fundamental design response to geometric complexity. It demonstrates how craft practices, even at a small scale, follow the same principles that underpin industrial moulding and casting: the balance between capturing detail and enabling release. The activity revealed not only technical insights about temperature control, sealing, and finishing, but also educational and social dimensions. Children engaged in the process, repurposing the moulds for play with plasticine, exemplifying how digital fabrication can seed creativity beyond its initial technical aims.

Figure 20. Completed soap chess pieces are ready for play.

Conclusions

The chess mould demonstrator illustrates how digital design can be transformed into tangible objects through simple, accessible means. It shows that 3D-printed moulds are effective tools for both technical exploration and creative expression. The case highlights the continuity between certainty, embodied in the precision of the digital mould, and risk, visible in the variability of casting materials and household conditions.

The creative mood didn't stop there. Using the same process, casting was also tested with a candle, with an equally successful result.

Figure 21. The technique can be used for custom candle making or dramatic games of Blitz chess.

In alignment with Craeft's mission, the chess demonstrator demonstrates how traditional forms can be reimagined through contemporary fabrication methods, producing outcomes that are educational, playful, and culturally resonant. It affirms that familiar cultural objects, when combined with experimental making processes, can generate technical insights and public engagement.

6 Educational activities

To facilitate educational activities presented as games, lessons were developed for Craeft's eLearning platform. These lessons guide users through the creation of basic tools, which can then be utilised to commence practising a craft or applying fundamental problem-solving techniques.

Following discussions and consultations with stakeholders and literature, with a particular emphasis on the History of Art, Cultural Heritage Institutions (CHI), curators, and Museum Educators, the decision was made to engage the public in participatory activities aimed at raising awareness of traditional crafts, especially their endangered status. These activities are designed to create analogue or digital immersive experiences that cultivate an appreciation for the skills, materials, and cultural significance of crafts, while simultaneously fostering a sense of responsibility for their preservation. The objective is to promote experiential learning, nurture emotional connections, facilitate knowledge transfer, and provide community support for artisans and heritage preservation. The initiatives are categorised as either analogue or hybrid experiences.

With the support and hosting of CH partners, the plans for analogue experiences include:

- Hands-on workshops where master artisans demonstrate and teach traditional techniques, and offer workshops where apprentices create their pieces.
- Living Heritage Events, where artisans work in real-time, allowing visitors to ask questions and try techniques. These exhibitions are to take place in public spaces, engagingly showcasing crafts and explaining the history and cultural relevance of the items and crafts.
- Citizen Craft Projects, inviting communities to contribute to a collective craft piece (e.g., a tapestry or mosaic) or organise 'repair cafes' where people learn to fix traditional objects, such as ceramics or textiles.

Hybrid experiences include material prepared on a computer and are group activities and may, optionally, include the use of electronic devices. We have planned for two types of activities.

The first regards the transmission of the cultural context of crafts. Narratives from the knowledge base are selected, authored, or retrieved from historical sources. Next, the narrative is analysed into theatrical scenes, and a storyboard is developed. Theatrical scenes are then converted into a prompt book (full script), a stage script to produce props and stage performances, and a playwright’s script. Illustrations can enhance storyboards by precisely delineating staging directions. Theatrical scenes can be further analysed into cinematographic scenes to determine the camera shots. Artificial intelligence (AI), specifically Large Language Models (LLMs) for text synthesis and Generative Adversarial Networks (GANs) for image synthesis, can optimise scripting and illustration efforts. The resulting scripts are subsequently utilised for the production of a theatrical play or a digital movie, requiring only basic equipment such as a smartphone for principal photography.

The second regards collaborative games that let people explore traditional techniques through games that simulate the crafting process and highlight the challenges artisans face. Two variants catering for different aspects of crafts are considered. The first regards crafting instructions for pairs or small teams collaborating to make a prescribed item through partial instructions that promote problem-solving skills. The challenges presented can be categorised as either mechanical or cognitive (puzzles). The latter

constitutes a role-playing game centred on the resource management and commercial aspects of craftsmanship, aiming to foster an understanding of sustainable practices and the connection between long-term profitability and the availability and sustainability of natural resources. This second variant demonstrates potential for digital and online adaptation, a prospect that will be evaluated based on the feedback received from its analogue counterpart.

6.1 Weaving Improvised

Weaving can be introduced through simple, improvised looms that repurpose everyday objects, lowering the barrier to entry while encouraging creativity. These activities demonstrate that effective weaving practice does not always require specialised tools.

e-Learning: https://www.craeft.eu/elearning/course/view.php?id=84

Table 12. Improvised looms

Chair	A sturdy chair is transformed into a loom by using its four legs to anchor warp threads. This cost-effective setup utilises ordinary furniture to create a large, stable frame with excellent tension control, making it ideal for substantial weaving projects that require structured support.
Card board	A portable, low-cost loom is made from a cardboard sheet with notches cut at the edges and ice cream sticks used as anchors. This setup is ideal for beginners and small projects, offering flexibility in size and spacing. It encourages experimentation with patterns and provides a simple introduction to warp–weft interlacing.
Plate	A round loom is created by cutting a disposable plastic plate into a sunflower-like shape. Each 'petal' serves as a warp anchor, producing a radial structure well-suited for circular patterns such as coasters, mandalas, or decorative hangings. This method introduces learners to symmetry and alternative loom geometries.
Learning to count	Paper weaving exercises teach mathematical concepts, including patterns, repetition, and symmetry. Learners cut coloured paper strips, weave them into grids, and arrange them in ordered or experimental sequences. The activity blends craft practice with problem-solving, supporting both creative expression and basic numeracy skills.

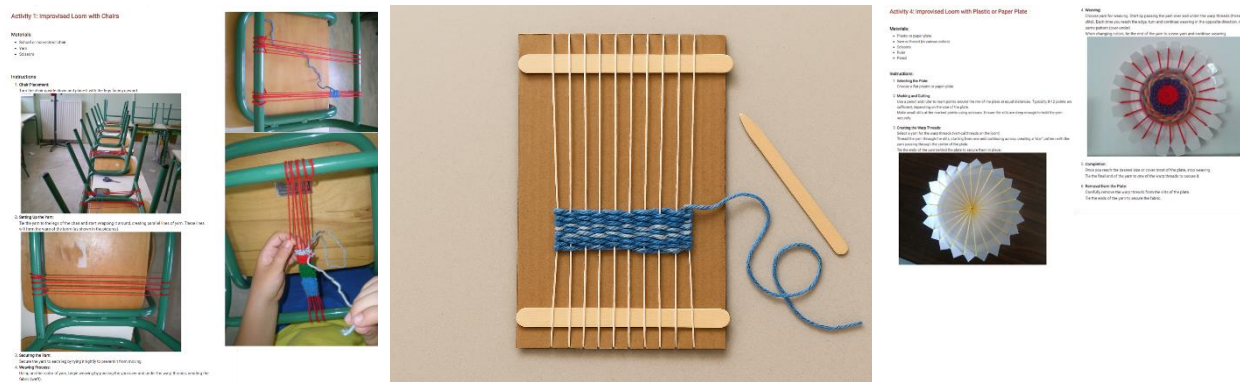
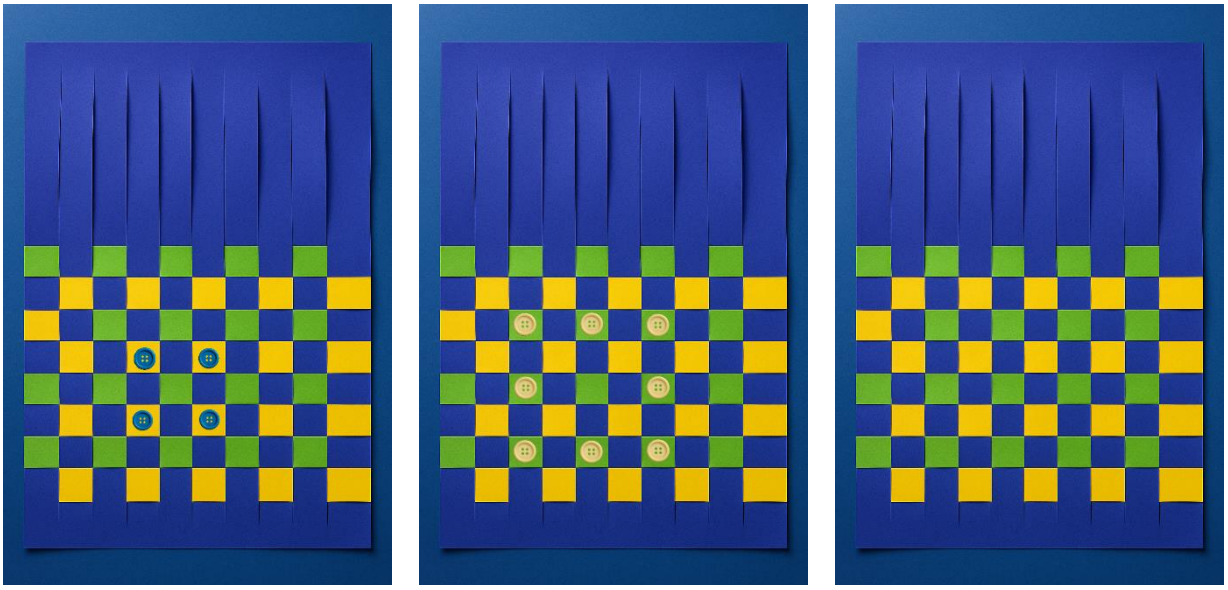


Figure 22. Screenshots from the eLearning platform showing weaving activities with simple items: a chair, a piece of cardboard, a plastic plate, and paper.



The images above illustrate a series of loom patterns produced through paper weaving exercises, in which learners cut coloured strips and interlace them into grids following ordered sequences. Each pattern is the visible outcome of a decision — which colour goes over, which goes under, when does the sequence change — made and repeated across the woven surface. Learners quickly discover that changing the order of the strips, or introducing a new colour at a different interval, transforms the visual result in predictable ways. This predictability is itself the lesson: **pattern is repeated structure**, and recognising, planning, and varying that structure is both a craft skill and a mathematical one.

6.2 Papier mâché sculpting workshop instructions

This workshop introduces participants to the creative process of papier mâché sculpting using simple, low-cost, and recycled materials. The activity encourages hands-on exploration, creativity, and sensory engagement while promoting sustainability through the reuse of paper waste. The workshop is designed to be adaptable, making it suitable for diverse learning abilities and inclusive educational settings.

Materials:

- Old books, old mail, catalogues, magazines, toilet paper, etc.
- A food blender (not required for toilet paper)
- White book binding glue (PVA)

Instructions:

1. Cut the paper into small pieces.
2. Soak the pieces of paper in warm water, preferably overnight.
3. Put in the blender one-part pieces of soaked paper with 3 parts water. Blend until it becomes a pulp. If you use toilet paper, you achieve the same effect by melting the paper with your hands.
4. Strain the pulp.
5. Press with your hand to remove most of the water. Water should not drip.
6. Add white book binding glue (PVA) and mix well by hand. The amount you use should be what will give you a uniform texture of pulp that won't rub off as you create your project.
7. You can colour your sculpture before and/or after the papier mâché dries (optional).

Recommendations for the special education context:

- Use illustrations of instructions to communicate visually.
- Let the children feel all the different textures while making the papier mâché, i.e. paper, soaked paper, pulp, papier mâché.

Note for consideration when in a special context: Every child participates as much as they can according to their abilities and impairments.

Table 13. Details of Papier mâché Sculpting Workshop

Title	PIOP - Papier mâché Sculpting Workshop
Goal	Creating sculptures using a simple, home-made paper pulp.

6.2.1 Materials

This subsection outlines the materials required for the papier mâché sculpting workshop. All materials are intentionally chosen to be easily accessible, affordable, and safe for use in educational environments. The use of recycled paper not only supports sustainability but also allows participants to engage with familiar materials in new and creative ways.

Table 14. List of material

Category	Specific Items	Notes

Paper	Old books, old mail, catalogues, magazines, toilet paper, etc.	Use readily available paper waste.
Adhesive	White book binding glue (PVA)	Essential for binding the pulp.
Equipment	Food blender	Not required if using toilet paper.
Liquid	Warm water	Needed for soaking and blending.




6.2.2 Instructions

The following step-by-step instructions describe the process of preparing papier mâché pulp and using it to create sculptures. The process is structured to be simple and flexible, allowing participants to work at their own pace. Clear sequencing supports understanding, while opportunities for tactile engagement make the activity especially suitable for learners with diverse needs.

Table 15. Instructions

Step	Action	Detail
1. Preparation	Cut the paper into small pieces.	This helps with soaking and blending.
2. Soaking	Soak the pieces of paper in warm water.	Preferably, leave them overnight for the best results.
3. Pulping	Blend: Use one part soaked, paper pieces with three parts water. Blend until a pulp is formed.	Alternative: If using toilet paper, simply melt the paper with your hands.
4. Straining	Strain the pulp.	Remove excess water before pressing.
5. De-watering	Press the pulp with your hand to remove most of the water.	The pulp should not drip water.

6. Glueing	Add PVA glue and mix well by hand.	Use enough glue to create a uniform texture that won't rub off during sculpting.
7. Colouring	Colour the sculpture.	Optional: Can be done before and/or after the papier mâché dries.

6.2.3 Recommendations

This subsection provides practical recommendations for facilitating the workshop in a special education context. The suggestions focus on inclusive participation, multi-sensory learning, and clear communication strategies to ensure that all children can engage meaningfully in the activity according to their individual abilities and needs.

Table 16. Recommendations

Context	Recommendation	Rationale
Communication	Use illustrations to enhance instructions and communicate visually.	Supports children with varied learning styles.
Sensory Input	Let children feel all the different textures (paper, soaked paper, pulp, finished mâché).	Provides a valuable tactile sensory experience.
Inclusivity Note	Every child should participate as much as they can according to their abilities and impairments.	Ensures the activity is accessible and tailored to individual needs.



Table 17. Recommendations

6.3 Storytelling and dramaturgic activities

6.3.1 Introduction

This section explores storytelling and dramaturgic activities as complementary pathways for engaging with traditional crafts beyond material making. It focuses on how narratives derived from craft-related visual sources—such as tapestries, cartoons, and historical imagery—can be analysed, reinterpreted, and transformed into scripts, storyboards, and performative or cinematic outputs. These activities extend craft education into interpretative and expressive domains, highlighting the narrative, symbolic, and cultural dimensions embedded in craft artefacts.

Building on the CRAEFT knowledge base, the approach presented here treats crafted objects and images not only as material outcomes but also as carriers of stories, social practices, and historical contexts. Visual motifs, gestures, colours, and compositional structures are decomposed and reassembled through dramaturgic processes, enabling learners to translate static artefacts into dynamic scenes. This process supports multiple representational forms, including woven-style imagery, simplified comic-strip drawings, colouring-book outlines, and pseudo-3D representations suitable for digital manipulation.

The section further demonstrates how contemporary digital tools, including AI-assisted image and video generation, can be integrated into storytelling workflows to support scriptwriting, illustration, and scene rendering. By combining human interpretation with computational methods, these activities create hybrid educational experiences that connect traditional craft aesthetics with modern modes of narrative production. The emphasis is placed on creative interpretation, iterative refinement, and critical engagement with cultural sources, preparing the ground for the discussion of training sets, interpretation strategies, and ethical considerations developed in the following subsection.

Figure 23. 19th-Century French Rustic Tapestry Cartoon, Depicting Youths at Play. Young people in a garden, possibly playing, with a swing or playful gesture; trees and natural setting.

Scene description for AI: Young woman on a swing, two companions (maybe one pushing, one watching). We decided

A mixture of AI and human designs is fused to create a storyboard and form the visual identity of the characters. In this example, the Images were generated with OpenAI's DALL·E model via ChatGPT (GPT-5, 2025).

Figure 24. Model of the visual characters as if woven into a tapestry

We initially model the visual characters as if woven into a tapestry. We then maintain the colour schemes to translate the image into similar styles, such as the woven representation on the left, or the simplified comic-strip drawing in the middle. The middle version can be further simplified by removing colours and retaining only outlines, making it suitable for colouring books (as demonstrated in stained glass design, see D3.1). The figure on the right shows the estimated body postures. This allows us to process the scene as pseudo-3D, facilitating virtual camera movements and scene relighting.

Figure 25. left: woven representation, middle: simplified comic-strip drawing, right: estimated body postures

Figure 26. Scenes from the AI-based video rendering. Video: https://youtu.be/opUW_tVNS50

Media: Same path (script → graphic novel panels → film scene) can be applied, with simpler gestures.

Figure 27. Different artistic renderings

6.3.2 Interpretation, Training Sets, and Ethical Cautions

The Rococo Garden swing sequence illustrates how visual storytelling, derived from tapestry imagery, can be reinterpreted through contemporary digital pipelines. In this process, training sets play a pivotal role: they provide the stylistic and iconographic cues that models use to render scenes in the manner of Aubusson or Rococo painting. Their composition determines not only technical fidelity but also the cultural context in which characters, gestures, and narratives are framed.

Because training sets often reproduce biases present in historical sources or in modern visual culture, creators must exercise caution. The Rococo idiom itself frequently carries undertones of eroticism and social play. When such imagery is re-staged through machine learning, there is a risk of unintentionally oversexualising characters, reinforcing gender stereotypes, or amplifying caricatures of femininity and masculinity. What may have been allegorical or symbolic in the 18th-century context can be exaggerated by algorithmic interpolation into forms that appear inappropriate or anachronistic today.

To mitigate these risks, two safeguards are essential. First, careful curation of training sets: selecting exemplars that emphasise compositional grace, textile fidelity, and narrative clarity, while avoiding gratuitous or ambiguous content. Second, a responsible interpretive stance by creators involves

establishing explicit design intentions (e.g., elegance, pastoral lightness, social interplay) and setting constraints that steer models away from problematic amplifications. In this way, the creative process aligns with both artistic authenticity and ethical responsibility, ensuring that CH imagery is transmitted as a vehicle of aesthetic refinement and narrative richness rather than as a vector of stereotype or sensationalism.

7. Conclusions

This deliverable has explored the intersection of serious games and traditional crafts education, highlighting the innovative potential of using game-based approaches to preserve and teach traditional skills. Through an examination of various game formats—digital, physical, and hybrid—this work has showcased the diverse methods available to engage learners in craft education.

The integration of serious games into traditional crafts education offers educational benefits. By creating interactive and immersive learning experiences, these games make traditional crafts more accessible and engaging for learners of all ages. The use of digital games allows for a wide-reaching impact, bringing complex craft techniques to a broader audience in an appealing and user-friendly format.

Physical and 3D-printed games provide tangible, hands-on experiences that are crucial for mastering the manual skills required in traditional crafts. These games enable learners to directly interact with materials and tools, fostering a deeper understanding and appreciation of the crafts. The improvised loom activities demonstrate the value of creativity and resourcefulness in education, showing that effective learning can be achieved with simple, everyday materials.

The educational activities outlined in this deliverable emphasise the importance of practical, experiential learning. By engaging in these activities, learners can develop not only technical skills but also critical thinking and problem-solving abilities. The blend of traditional techniques with modern educational tools reflects a forward-thinking approach to preserving CH while adapting to contemporary educational needs.

In conclusion, this deliverable highlights the transformative potential of serious games in traditional crafts education. By combining the richness of traditional skills with the engagement of game-based learning, we can create dynamic and effective educational experiences that inspire and educate future generations. This work serves as a foundation for further innovation and development in the field, aiming to enhance the way we teach and preserve traditional crafts.

Annex A. Board Game Assets

A.1 Rules

The following pages reproduce the game's rules in the form provided to players. They document the component list, card categories, setup procedure, and the two-phase gameplay loop, concluding with the end-game / winning conditions.

Figure 28. Rulebook pages (A.1): overview of the game premise; component inventory; definitions of card categories (material, seller, tool, upgrade); step-by-step setup; main gameplay phases and actions; and end-game/scoring conditions.

A.2 Market Board

The market board structures the shared play area. It defines the market row (available cards) and visually standardises where offers are presented and refreshed between turns.

Figure 29. Market board (A.2): shared board layout showing the market row slots used to display the currently available cards.

A.3 Player Board

Each player uses an individual player board to manage their resources and progression. The board provides dedicated spaces for materials, crafted items, tools, and upgrades, supporting clear state tracking during play.

Figure 30. Player board (A.3): per-player layout with dedicated slots for materials, crafted items, tools, and upgrades, enabling consistent tracking of each player's evolving capabilities.

A.4 Material Cards

Material cards represent the raw inputs used in crafting. Each card pairs a material image with a short description and a QR code (for optional extended information and/or links to the underlying craft documentation).

Figure 31. Material cards (A.4): representative examples (e.g., marble, wood, kaolin, clay, silica sand) showing the material identity, short explanatory text, and QR code for extended reference.

A.5 Tool Cards

Tool cards represent equipment that players can acquire and use to enable or improve crafting actions. They encode tool identity and intended role in the crafting workflow, supporting learning-by-play around tooling and technique.

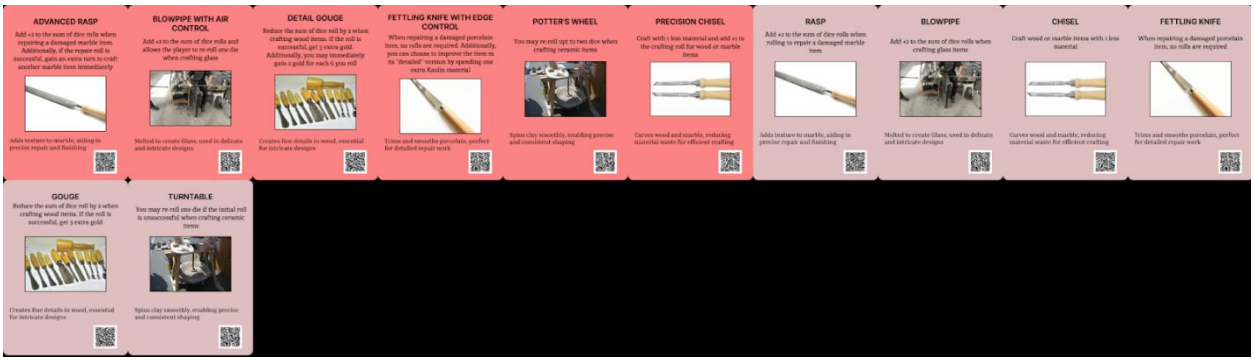


Figure 32. Tool cards (A.5): representative tool set illustrating the tool deck design, including tool identity, brief functional description, and QR code references (examples include rasps, chisels, blowpipe-related tools, gouges, and workshop equipment such as

A.6 Upgrade Cards

Upgrade cards represent longer-term improvements (techniques, infrastructure, or workflow enhancements) that shift a player's capabilities over time. They provide the game's main progression layer, enabling more efficient or higher-value crafting strategies.

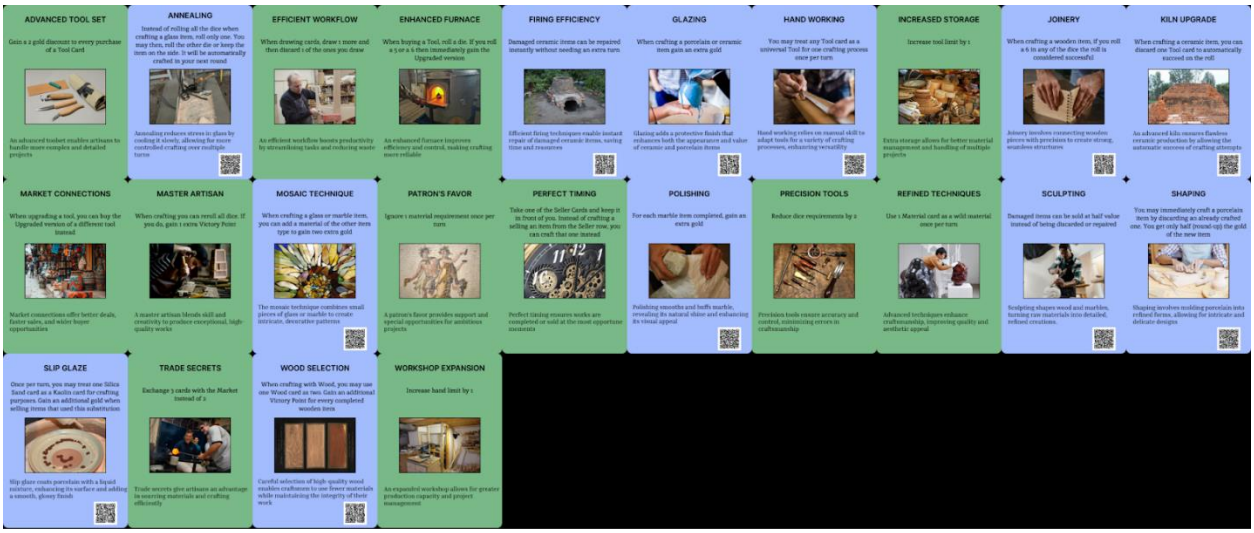


Figure 33. Upgrade cards (A.6): progression deck illustrating technique/workflow/infrastructure upgrades (e.g., kiln upgrade, glazing, annealing, joinery, refined techniques, workshop expansion), each presented with a short description and QR reference.

A.7 Seller Cards

Seller cards represent craft products that can be produced and sold. They encode the target item, its requirements (e.g., materials/conditions), and its value/scoring contribution, linking craft content to gameplay objectives.

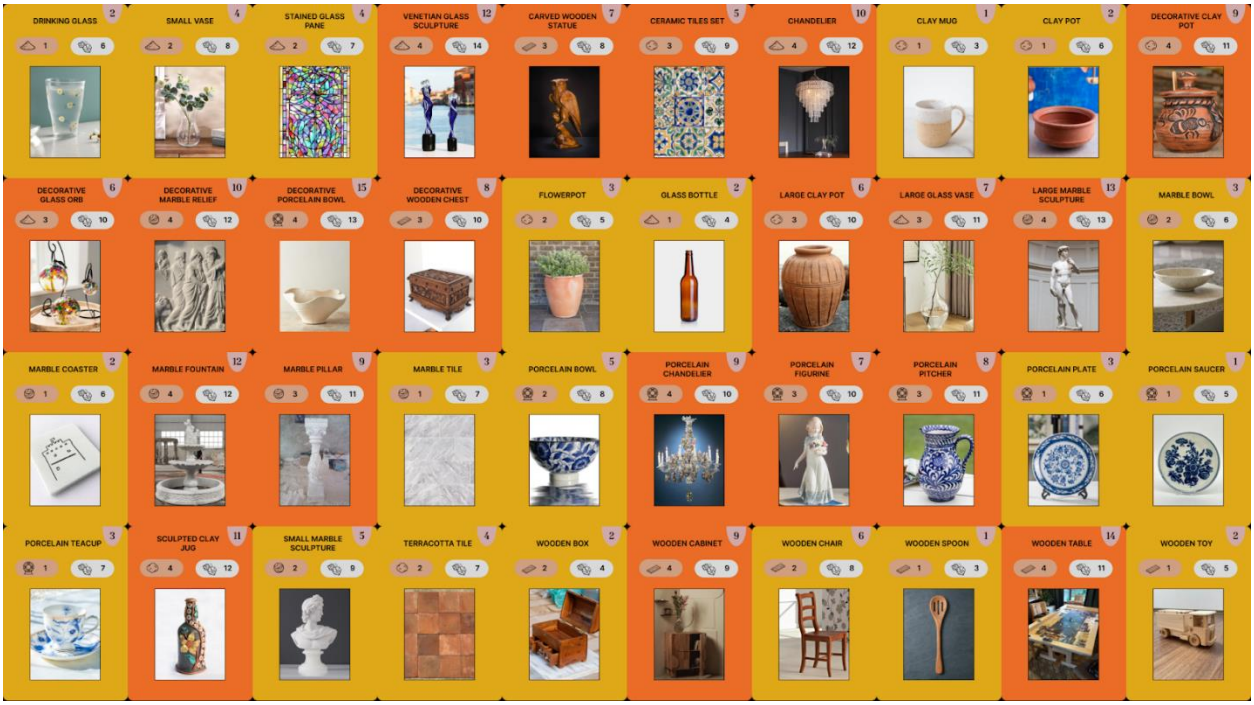


Figure 34. Seller cards (A.7): catalogue of craft products across materials and categories (glass, ceramic/porcelain, wood, stone/clay), showing item imagery and gameplay attributes used to drive crafting and selling decisions.

A.8 Playtesting Photos

The following screenshots document playtesting sessions by capturing representative game states. They illustrate how the market, player boards, card rows, and tokens are arranged during play, providing evidence of component usability and table readability.

Figure 35. Playtesting screenshots (A.8): representative gameplay states showing the shared market area, multiple player boards, card rows, and token placement during playtesting.

A.9 Playtesting Review Form

This form was used to collect structured feedback from playtesters. It captures perceived clarity of rules, enjoyment, difficulty, and the degree to which the game supports learning about traditional crafts, alongside space for qualitative comments.

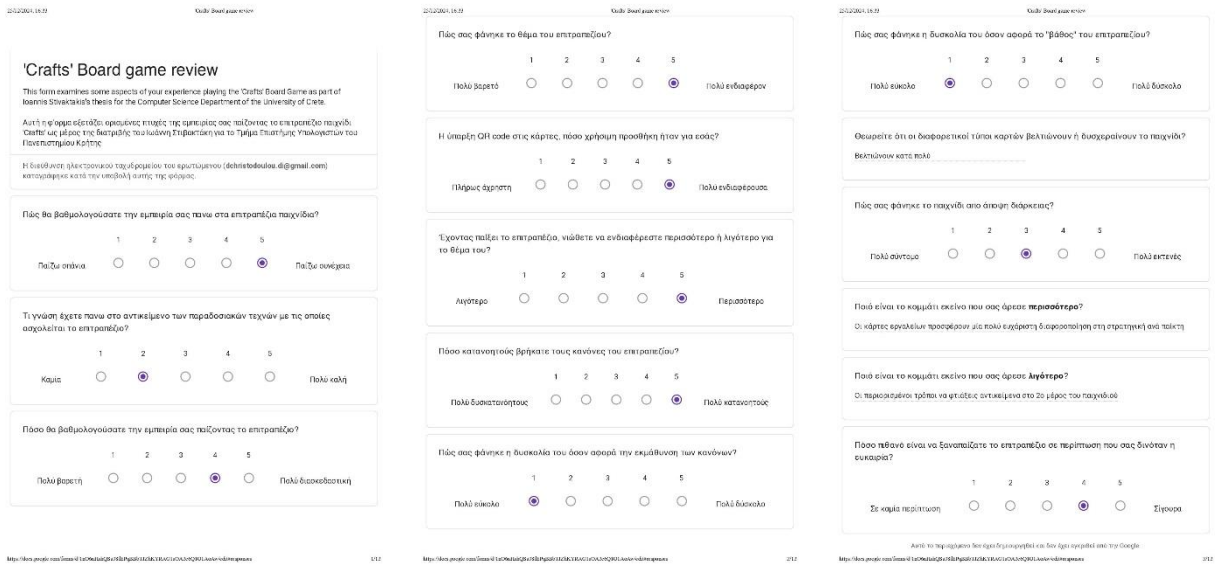


Figure 36. Playtesting review form (A.9): three-page questionnaire used during evaluation to gather Likert-scale ratings and comments on gameplay clarity, engagement, perceived learning outcomes, and difficulty.

Annex B. Chess: Market Analysis

B.1 Introduction

This market analysis has been prepared within the framework of the Craeft project to justify the selection of chess as the basis for a handcrafted demonstrator object. The project team created a bespoke chess set using 3D-printed moulds and casting materials such as soap and wax. The choice of chess was deliberate: it is a game with near-universal recognition, rules already familiar to most audiences, and a market that spans digital and physical domains. By grounding our design in a game of proven popularity and cultural visibility, we ensure that the handcrafted set speaks to broad publics while exemplifying the project's focus on craft innovation.

Chess resonates across digital and physical domains and has witnessed a strong resurgence in recent years. Online platforms, e.g. Chess.com (200 million members) and Lichess, attract millions of players daily, while millions of physical sets are sold annually, ranging from inexpensive educational kits to luxury collector's editions [30, 26]. The enduring institutional legacy of chess is upheld by elite tournaments sanctioned by the International Chess Federation (FIDE). However, chess has simultaneously evolved into an e-sport and a form of live entertainment, as exemplified by Twitch events like PogChamps [33]. Social media further amplifies this expanded reach. Influential social figures, or 'influencers,' draw millions of followers through streaming platforms [29].

Chess occupies a singular position as both a game of strategy and a cultural artefact. Its appeal is global, cutting across age, geography, and social class. Evidence of this popularity is found in several domains: online platforms host millions of daily matches; international tournaments attract federations from nearly every nation; and physical sets remain staples in households, schools, and cafés. What distinguishes the present moment is the convergence of tradition and technology. Streaming platforms and esports events have propelled chess into the digital spotlight, while series such as The Queen's Gambit [ISAN 0000-0007-70BA] have sparked renewed enthusiasm [31, 32]. The result is a landscape in which chess is simultaneously an ancient intellectual pursuit and a modern entertainment phenomenon.

In this sense, chess demonstrates how cultural practices adapt to new conditions while retaining their core identity. The enduring fascination lies in its blend of simplicity and depth: a finite set of rules gives rise to an infinite space of possibilities. Chess continues to attract newcomers while challenging seasoned players. Its popularity, therefore, is not merely a matter of numbers but a reflection of its unique capacity to evolve while maintaining continuity.

B.2 Onsite Market

Chess continues to thrive in its most familiar settings: schools, clubs, cafés, and households. These environments preserve the game's traditional social role, where learning often occurs informally, through family members, peers, or local mentors. For many children, the school chess programme provides an introduction to the game, introducing rules and habits of concentration, patience, and strategy [20].

Clubs and community groups extend this learning into more sustained practice. Here, players develop styles, rivalries, and friendships, embedding chess within a rhythm of weekly or monthly meetings. The

café game, by contrast, represents chess at its most casual, as an open-ended conversation between strangers or friends, with the board serving as a shared language. Physical sets remain indispensable in these contexts, and their continuing sales reflect the enduring appeal of tangible play.

The persistence of casual and club play demonstrates that, even in an era dominated by digital platforms, chess retains a face-to-face social practice.

B.2.1 Global Chess Set Market

The chess set market provides a material index of the game's popularity. Millions of sets are sold annually across traditional and digital retail channels, with values estimated in the billions. The range is striking: from inexpensive plastic boards designed for schools and casual players, to finely crafted wooden and luxury sets intended as collector's items or decorative pieces.

Retail data show surges in demand following The Queen's Gambit, with U.S. chess set sales increasing by 87% and wooden sets leading the trend [32]. eBay reported that sales of chess sets and accessories rose by 215% in that period [31]. The chess set market thus mirrors the trajectory of the game itself: at once traditional and modern, grounded in centuries-old practices yet invigorated by digital media and new audiences.

B.2.2 Popular Types of Chess Sets

Market segmentation reveals three broad categories:

- Standard sets, often wooden or plastic, are used in schools and clubs [22].
- Luxury sets, crafted from fine woods, glass, or marble, are valued as both functional objects and cultural symbols [23].
- Electronic sets, such as those produced by Millennium Chess, which integrate sensors and connectivity to digital platforms [24].

These categories reveal the flexibility of chess as both a material culture and a technological artefact. The game adapts to diverse contexts: functional in the classroom, ornamental in the study, and innovative in the digital domain.

B.2.3 Sales Channels

Chess sets are sold online and in traditional retail. Online retail has become the dominant channel, driven by its convenience and breadth. eBay reported a 215% surge in chess sets and accessories during 2020, demonstrating the power of e-commerce [31]. Broader board-game retail statistics likewise show online channels leading growth, while physical toy and hobby stores remain important for tactile purchases [25, 27].

The in-store experience, seeing, touching, and even testing pieces on a board, provides a dimension of assurance and immediacy that online transactions cannot replicate. Seasonal trends further reinforce this channel, with holidays and local tournaments driving peaks in demand.

B.2.4 Consumer Demographics

The purchase of chess sets spans a broad demographic spectrum across age and income, reflecting the game's accessibility. Children often receive chess sets as gifts, and schools purchase them in bulk as part of educational programmes [20]. Teenagers and young adults, influenced by online platforms and streaming culture, increasingly adopt the game as a pastime and competitive challenge. Adults in their thirties to fifties often purchase sets for domestic use. Seniors are likewise significant consumers, turning to chess as a means of maintaining mental acuity and social engagement [28].

B.2.5 Seasonal Trends

The demand for chess sets follows recognisable seasonal rhythms, shaped by cultural calendars and competitive cycles. The most pronounced peak occurs during holiday seasons. Christmas, in particular, drives a surge in sales, with U.S. chess set sales increasing by 87% in the weeks after The Queen's Gambit [20]. Retail analysts note similar peaks around tournaments and school terms, consistent with broader board-game sales cycles [25].

B.2.6 Impact of Technology

Technology has reshaped the chess landscape, altering how the game is played and the value of physical sets. Chess.com and Lichess anchor a digital ecosystem of millions of players [30, 26]. AI systems such as AlphaZero and Stockfish have transformed training [19].

Yet physical boards remain irreplaceable for tactile and social reasons. This coexistence of digital practice and material artefact underscores why the Craeft project's handcrafted set is strategically placed: it speaks to a culture that values both physical craftsmanship and digital innovation.

B.3 Online Market

The digital era has transformed chess from a board game between two players into a global networked activity. Platforms such as Chess.com, with over 200 million registered members and more than 20 million games played daily, demonstrate the unprecedented scale of participation [30]. Millions of matches unfold daily, reflecting its broad reach and accessibility. The open-source ethos of Lichess is attributed to its millions of games each day, cultivating a strong community identity that contrasts with the commercial orientation of other platforms [26]. Smaller arenas, including FIDE's official online platform, add further layers of competitive play, offering structured formats tied to the international federation.

What emerges from this constellation of platforms is a democratisation of access. Players once limited to local clubs now compete across continents, encountering a diversity of styles and skill levels that accelerate learning and foster resilience. Importantly, the immediacy of digital play alters the rhythm of engagement. Whereas traditional chess often required deliberate planning of time and place, online environments invite casual encounters and rapid experimentation, thereby expanding the game's reach into everyday life.

B.3.1 Competitive Chess and Esports

At the elite level, chess is institutionalised through FIDE, which unites more than 200 national federations and administers the world championship cycle [21]. These events serve as benchmarks of excellence, where preparation, psychological endurance, and cultural prestige converge. The traditional tournament structure is in continuity with the game's long institutional history, while still allowing for innovation in format and presentation.

In parallel, chess has entered the domain of esports, a transition that reflects the game's adaptability to new media ecologies. Events such as PogChamps, which feature popular streamers and celebrities, have drawn millions of audiences [33]. Here, the focus shifts from elite performance to entertainment and community engagement. The spectacle of well-known figures learning, struggling, and occasionally excelling at the game reframes chess as competitive and playful.

The coexistence of formal tournaments and esports events illustrates the dual identity of chess in the 21st century. On one hand, it remains a discipline of rigour, demanding years of study and dedication. On the other hand, it thrives as a cultural performance, amplified by streaming technologies and online audiences. These domains expand chess's reach. The former sustains its mastery tradition. The latter attracts new publics who encounter the game as spectacle before pursuing it as practice.

B.3.2 Social Media & Streaming

The rise of social media has transformed chess into a form of continuous public performance. Platforms such as Twitch and YouTube now host communities in the millions, where popular figures like Hikaru Nakamura maintain direct, daily contact with audiences. His channel alone surpasses two million followers [29]. These streams blur the boundary between pedagogy and entertainment: lessons, blitz sessions, and banter unfold in real time, making the once-private domain of high-level play an accessible spectacle.

The influence of popular culture has further accelerated this shift. The Queen's Gambit (2020) did more than dramatise the life of a fictional prodigy; it catalysed renewed interest across demographics. In the months following its release, online registrations surged, chessboard sales spiked, and search traffic for basic chess terms rose to unprecedented levels [32, 31]. Streaming amplified this surge, with established content creators translating new enthusiasm into sustained engagement.

In this environment, chess is no longer confined to the board or the tournament hall. It circulates as a narrative, a performance, and a shared experience. The streaming era demonstrates that the popularity of chess cannot be measured solely by competitive participation; it must also account for the game's capacity to generate stories, communities, and cultural moments in digital space.

B.4 Conclusion

From online platforms to luxury markets, chess demonstrates resilience and adaptability. Its broad popularity, recognisability of rules, and cross-demographic appeal make it an ideal medium for craft experimentation. In choosing chess as the focus of a handcrafted set, Craeft aligned with a thriving, global market while also contributing an artisanal interpretation of a universally known game.

The handcrafted chess set developed in Craeft is justified and market-aligned. It draws strength from the game's cultural familiarity and benefits from its strong commercial presence. It exemplifies how craft innovation can connect with a global audience already predisposed to understand and value the object.

Annex C: Domestic Lab Notes

C.1 Manufacturing Soaps with 3D Printed Moulds

The moulds were designed and printed with a 3D printer. The moulds were based on chess pieces. The existence of these moulds gave rise to creative experimentation and testing of materials, to establish what kind of items can be produced through casting, utilising everyday equipment.

'What can we make with these moulds?'

C.2 Materials

C.2.1 Plasticine

A small series of experiments followed. First, I tried plasticine. Easy to work with, but extremely difficult to demould, as it deformed as soon as it was pulled from the mould. Despite the good intentions, the shapes were distorted, and the pieces looked more like abstract art than strategic pawns.

C.2.2 Clay

Experimentation with clay. The original approach was to place clay in each mould half separately and then join them together during closure. However, this turned out to be time-consuming and technically unstable - the material could not remain homogeneous at the joint line, and the result was unsatisfactory.

Figure 37. Moulding did not result in favourable outcomes for plasticine (left) and clay (right).

So the mould has temporarily passed… into other hands: my kids started playing with plasticine using the moulds, finding creative joy where I saw technical dead ends.

Figure 38. The plasticine and clay failures were reused for play.

C.2.3 Soap

This is how the idea was born to try something different: to mould soap. Although I had no previous experience with this technique, I found along the way that the necessary equipment was already available in my home. The goal was clear: to create a complete soap chessboard based solely on these moulds.

To begin one's soap-making adventure, these are - theoretically - the essentials. I say theoretically, because in practice I discovered them gradually, one by one, through failures, with the hope that 'this time it will work'.

The list I wish I had before I started:

- Chess moulds (printed with a 3D printer – was the original reason for it all)
- Soap base
- Scale (to weigh exactly 100g of soap each time – crucial for colour dose)
- Knife (to cut soap)
- Coffee pot (to melt the soap)
- Chopstick or spoon (to mix)
- Gas lighter & lighter
- Rubber bands (to keep the moulds tightly closed)
- Oil (to make the pieces easier to demould)

- A glass (for the oil)
- Cotton swabs (to spread the oil carefully on the mould)
- Alcoholic lotion with a sprayer - prevents bubbles in the soap.
- Water or soap colour

Scissors (to finish – small fixes, big results)

Figure 39. The equipment and materials for this activity can be found in a household.

As much as it looks like a professional installation, all this is already there in most kitchens. I, at least, didn't buy anything other than the soap base and the paint. Everything else was just a matter of... imagination and ingenuity.

Before I started melting the soap, with the help of a little helper, we brushed the inside of the moulds with a little oil, using cotton swabs. This simple but important movement ensured that the soaps would be demoulded easily and without sticking to the walls of the moulds.

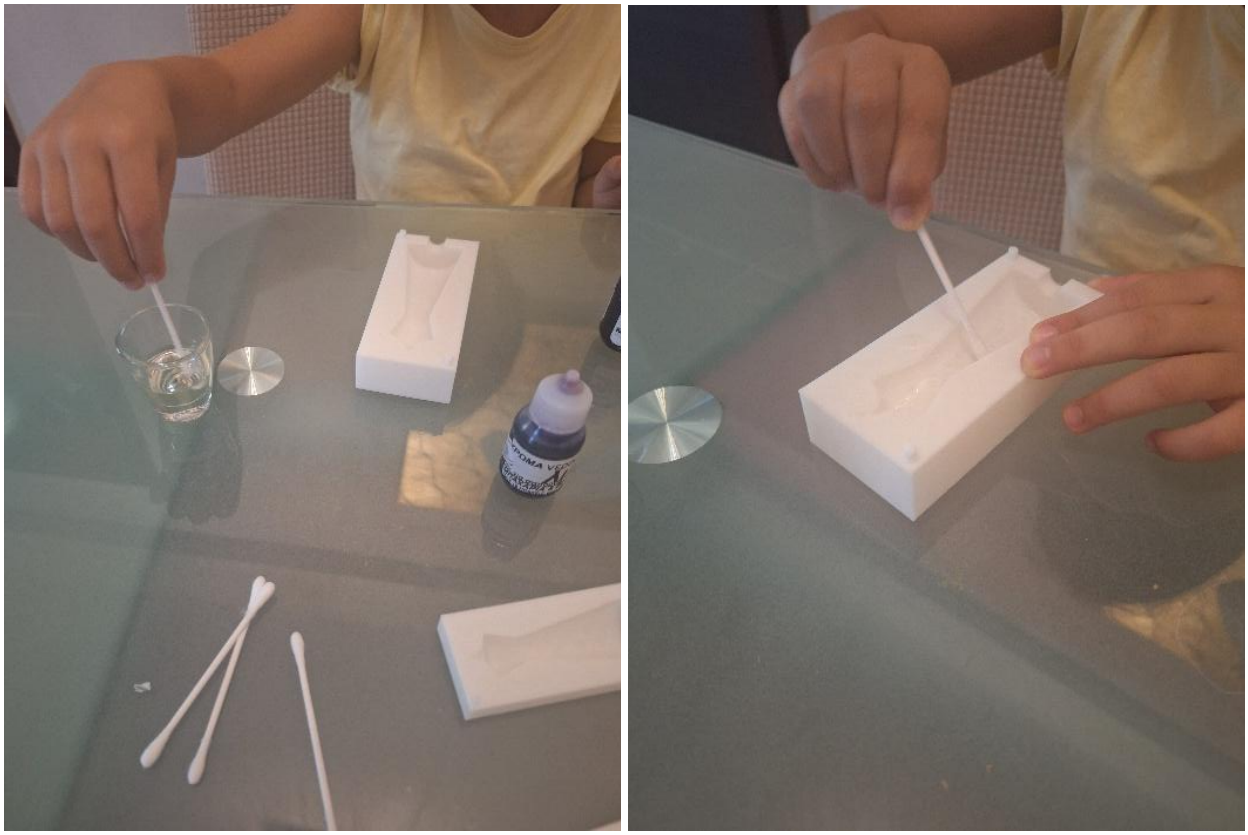


Figure 40. Conditioning the moulds with oil for easy release.

Moving on to melting the soap, the first attempt was rather instructive—and a bit disappointing. I placed the kettle very close to the stove, on high heat, causing the soap base to 'boil', foam and eventually turn black. The smell was like burnt wax, and the material became useless. It was the moment I realised that success requires patience – and the right temperature.

On the second try, with more care, I melted the base on low heat, keeping the kettle away from the flame and stirring constantly with a wooden stick. The soap melted smoothly and evenly.

Figure 41. Melting the soap base carefully on low heat. Adding consistent colour: one drop per 100 g of soap.

Then colour was added. I note that I weighed and melted 100 grams of soap each time so that I could accurately add one drop of colour per 100 grams. This way, I ensured consistent and uniform colouring in each batch. The material was then poured into the moulds, which were sealed with rubber bands to prevent them from opening during casting.

The first pieces, however, had holes and small but obvious bubbles. Looking for a solution, I tried alcohol spray on the mould before closing, and in the mouth after filling. This method helped prevent bubbles, with a clearly improved result. Spraying prevented bubbling and contributed to a smoother surface.

At the same time, to fill in the details of the mould and avoid gaps, after the liquid soap was poured, the mould was tapped lightly on the table for a few seconds. This simple step improved the quality of the final result.

And so, through mistakes and experimentation, I managed to make the most beautiful handmade soap chessboard that I could imagine. With tools I had at home, no special equipment, but with a lot of appetite, patience, and the joy of the creator who sees something take shape in his hands – and it smells good!

Figure 42. Casting the soap into tightly sealed moulds.

After casting, I waited a little while for the soap to start setting and then placed the moulds in the freezer. This way, the curing happened faster, and I could continue without much delay. After the soap had hardened, I carefully demoulded it. I made sure to preserve all the beautiful and detailed shapes of the pieces.

Figure 43. Unmoulding the finished soap chess pieces.

Sometimes, after demoulding, I would notice that the soaps had little unwanted residue or excess material on the edges. This was because the mould had not fitted perfectly, and small leaks had developed during casting. With a knife or scissors, I carefully cleaned these imperfections so that the pieces came out clean and neat.

C.2.4 Wax

The creative mood didn't stop there. Using the same process, casting was also tested with a candle, with an equally successful result.

The thought now is: maybe the next chessboard is made… entirely of candles?

C.3 Conclusions

This experimentation highlighted how a simple 3D printed design can be a starting point for a course of material exploration, even with simple, everyday means. The transformation of moulds into practical tools for the production of objects highlighted the possibility of their use in creative, educational or even artistic contexts.

Annex D: Desk research catalogue: communities and 3D-printable craft-toy designs

D.1 Communities of 3D printable designs

Physical games introduce the concept of a craft more simply and abstractly, making traditional skills accessible and engaging for learners of all ages. One such example that we have tested is the potholder loom, a straightforward yet effective tool for teaching the basics of weaving.

Communities like Thingiverse, MyMiniFactory, and Cults3D have become central hubs for the global 3D printing community. These platforms facilitate the sharing, discovery, and customisation of 3D printable designs, catering to a wide range of interests and skill levels.

Thingiverse is one of the largest and most well-known repositories for 3D printable models. Created by MakerBot, it offers a vast collection of user-generated designs that are freely available for personal use. The platform encourages collaboration and innovation, allowing users to upload their creations, share modifications, and provide feedback on designs.

MyMiniFactory focuses on ensuring high-quality, curated content. It collaborates with designers to provide a marketplace for premium designs while also offering a substantial number of free models. It supports a variety of creative projects, from hobbyist endeavours to professional product development, emphasising the importance of quality and reliability.

Cults3D is another prominent platform that blends free and paid 3D printable models. It is known for its vibrant community of designers who showcase their work and monetise their creations. Cults3D supports a diverse range of categories, making it a valuable resource for enthusiasts and professionals alike.

These communities not only provide access to a wealth of 3D printable designs but also foster a sense of collaboration and learning. They enable users to explore new ideas, share knowledge, and connect with other enthusiasts, driving the growth and evolution of the 3D printing ecosystem.

D.2 Mapping

Table 18. 1 Platform profiles (desk research sources).

Platform	Access	Curation & Quality	Strengths for educational reuse	Typical caveats
Thingiverse	Mostly free	Community-driven	Very large corpus; strong remix culture; fast ideation	Documentation quality varies; printability is inconsistent

MyMiniFactory	Mixed	More curated	Higher likelihood of "printable as listed"; designer-led documentation	Some content behind paywalls; licences vary
Cults3D	Mixed	Marketplace, community	Many niche tools and variants; an active designer community	Mixed documentation; licences vary; paid items common
Printables	Mostly free	Community, print profiles	Often includes practical print settings and iteration feedback	Smaller corpus than Thingiverse; coverage varies

Table 19. [TBD].2 Design catalogue (shortlisted exemplars).

ID	Family	Figure(s)	Educational relevance
L01	*Mini loom*	Figure 44	Makes interlacing and tension visible & tangible
L02			Same; alternative geometry/design choices
L03	*Loop loom*	Figure 45	Stepwise weaving abstraction; novice-friendly
L04			Alternative design option for comparison
L05	*Bracelet loom*	Figure 46	Patterning; sequencing; fine motor skills
L06			Variant geometry; potential robustness differences
L07	*Bead loom*	Figure 47	Precision patterning; tension management
L08			Adjustable constraints; multiple artefact sizes
P01	*Pottery toy/tool*	Figure 48	Demonstrates rotation-based forming concepts
P02			Alternative design; comparison point
P03	*Pottery accessories*	Figure 49	Tool affordances and surface manipulation
P04			The tool set enables varied gestures
P05	*Clay rolling stamps*	Figure 50	Pattern transfer; repeatability; design variation
P06			Ergonomics/handling; imprint consistency

D.3 Looms

D.3.1 Mini weaving loom

A 3D-printable mini loom is a small handheld device for weaving small pieces of fabric, suitable for hobby and educational use. Typical designs include a rectangular frame with evenly spaced pegs/slots to hold warp threads; a heddle bar that separates warp threads into two sets to ease passing the weft; a shuttle to guide the weft; and a beater to compact the weave. The 3D-printable approach supports accessibility and adaptation (dimension changes, feature tweaks), and designs are commonly shared via maker repositories.

D.3.2 Potholder loom

A potholder loom supports weaving by placing elastic loops on a grid and interlacing them into a finished item. In CRAEFT, the loom was printed from an online design and mounted on a wooden panel for stability. Demonstration material (video + step-by-step instructions) was produced to make the activity replicable. Educationally, the activity introduces weaving fundamentals (tension, interlacing, pattern creation) in a hands-on way and illustrates how digital fabrication can support traditional craft learning.

D.3.3 Rubber band bracelet looms

Rubber band bracelet looms typically use a small printed base with evenly spaced pegs/pins. Rubber bands are stretched and looped around the pegs in specific sequences, then manipulated with a small hook tool to pull bands through previous loops. These designs are portable and emphasise sequencing, repetition, and pattern formation.

D.3.4 Bead looms

Bead looms are typically a small printed frame with pegs/slots for warp threads, enabling consistent tension and organised bead placement. Designs may include a heddle bar to separate warp threads and assist in forming more intricate patterns. Practical finishing considerations include how warp thread ends are managed (some approaches require backing with ribbon/Ultra Suede; others leave fewer ends and simplify finishing).

D.4 Pottery wheel, tools, and stamps

Printed pottery wheels and tool sets support introductory learning by making tool–material interactions explicit (pressure, friction, surface finish) while remaining small and portable. Rolling stamps enable repeatable pattern transfer to clay surfaces and illustrate how digital patterns translate into physical textures; multiple stamp variants provide rapid design exploration at low cost.

D.4.1 Mini weaving loom

A 3D printable mini loom is a small, handheld device designed for weaving small pieces of fabric, perfect for hobbyists and educational purposes. This loom is compact and portable, making it easy to use anywhere. The key advantage of a 3D printable loom is its accessibility and customizability, allowing users to create their own loom using a 3D printer and tailor it to their specific needs.

The loom consists of a frame, which is the main structure that holds everything together. This frame is rectangular and features pegs or slots along the top and bottom edges. These pegs or slots are evenly spaced and are used to hold the warp threads in place, which are the threads that run vertically on the loom. When printed, the frame is typically made from durable plastic materials like PLA or ABS, ensuring stability and longevity.

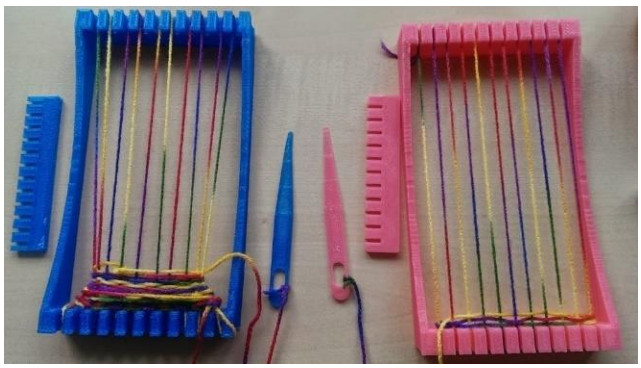
Central to the loom's functionality is the heddle bar, a movable bar with slots or holes that allow the warp threads to be separated into two sets. This separation is crucial as it makes it easier to pass the weft thread (the horizontal thread) through the warp threads, simplifying the weaving process. The heddle bar can be printed to fit perfectly within the frame, ensuring smooth operation.

The shuttle is another essential part of the loom. It is a small, flat piece used to hold and guide the weft thread through the warp threads. By wrapping the weft thread around the shuttle, users can easily pass it back and forth through the warp threads to create the woven fabric. A 3D printable shuttle can be customised in terms of size and shape to suit different weaving projects.

Lastly, the beater is a tool used to push the weft thread tightly against the woven fabric, ensuring a neat and compact weave. The beater helps maintain the tension and alignment of the threads, resulting in a uniform and professional-looking piece of fabric. The design of the beater can be adjusted and printed to match the user’s specific weaving requirements.

The 3D printable concept allows users to download and print all the components of the mini loom from various online repositories, such as Thingiverse, MyMiniFactory, Cults3D, and PrusaPrinters. These platforms offer a variety of loom designs that can be freely downloaded and customised. Once the STL files are downloaded, they can be loaded into a 3D printer’s slicing software, adjusted for print settings, and printed. The printed parts can then be easily assembled to form a complete loom.

In addition to providing a cost-effective and customizable solution for weaving, a 3D printable mini loom also promotes creativity and innovation. Users can modify the design files to create unique loom configurations, add additional features, or improve existing ones. This flexibility makes 3D printable looms a valuable tool for both beginners and experienced weavers, offering endless possibilities for weaving small pieces of fabric.



https://www.thingiverse.com/thing:305056

https://www.thingiverse.com/thing:2449174

Figure 44. Mini weaving looms examples

D.4.2 Potholder loom

A potholder loom is a simple device that allows users to create potholders by placing elastic loops on the loom and weaving them together. The design for this game was sourced online, and we utilised a 3D printer to bring it to life. The process began by downloading a digital design for the loom, which was then printed using a 3D printer. The printed loom components were subsequently secured onto a wooden panel to provide stability and ease of use.

The resulting toy is not only functional but also serves as an educational tool. To demonstrate its use, we created a detailed demonstration video and step-by-step instructions. The video guides users through the entire process of setting up the loom, placing the elastic loops, and weaving them to create a finished potholder. These resources are designed to be easily accessible and user-friendly, ensuring that learners can follow along and replicate the process independently.

Educationally, the potholder loom game introduces the fundamental concepts of weaving in a hands-on and engaging manner. By interacting with the loom, users can understand the basic principles of tension, pattern creation, and the interlacing of threads, which are essential skills in traditional weaving crafts. The tactile experience of manipulating the elastic loops and seeing the potholder take shape provides a deeper understanding of the craft compared to purely theoretical learning.

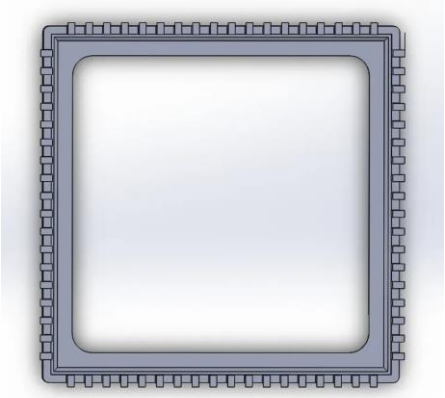
The use of a 3D printer in creating the loom adds an innovative dimension to the project, demonstrating how modern technology can be harnessed to revive and teach traditional crafts. The combination of digital design and physical assembly bridges the gap between contemporary technology and age-old crafting techniques, highlighting the versatility and potential of integrating these fields.

Feedback from users has been overwhelmingly positive. Participants appreciated the simplicity and clarity of the instructions, as well as the satisfaction of creating a functional item with their own hands. The physicality of the loom, combined with the educational resources, provides an enriching learning experience that goes beyond mere observation.

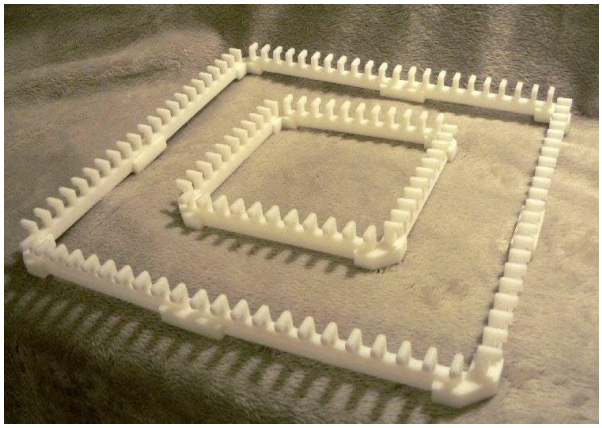
Looking forward, we aim to expand this concept by exploring other simple weaving devices and crafts that can be similarly designed, 3D printed and demonstrated. By creating a series of such physical games, we

can build a comprehensive educational toolkit that covers various aspects of traditional crafts, each with its instructional video and printed materials.

In conclusion, the potholder loom project exemplifies how physical games can simplify and abstract the concepts of traditional crafts, making them accessible to a wider audience. By combining 3D printing technology with hands-on crafting, this game offers a tangible and interactive way to learn about weaving. The success of this project encourages further exploration and development of similar educational tools, ensuring that the knowledge and appreciation of traditional crafts continue to thrive in modern times.



https://www.printables.com/model/150671-potholder-loom



https://www.thingiverse.com/thing:104503

Figure 45. Potholder loom example

D.4.3 Rubber band bracelet looms

A 3D printable rubber band bracelet loom is an innovative tool that allows users to create intricate and colourful bracelets using small rubber bands. Designed to be compact, portable, and easy to use, these looms are perfect for children and hobbyists alike.

The loom consists of a rectangular base that forms the foundation, which may be designed as a single piece or as multiple pieces that can be connected. The base is typically made from a sturdy plastic like PLA or ABS to ensure durability and is usually small enough to be handheld or fit comfortably on a desk.

Pegs or pins are evenly spaced along the base and can be arranged in various patterns, such as a single row, double row, or staggered configuration, depending on the complexity of the bracelet designs. These pegs act as anchors for the rubber bands, allowing users to stretch and loop the bands in different configurations. Pegs are generally cylindrical with a slight taper to hold the rubber bands securely, and some designs include grooves or notches to prevent slipping.

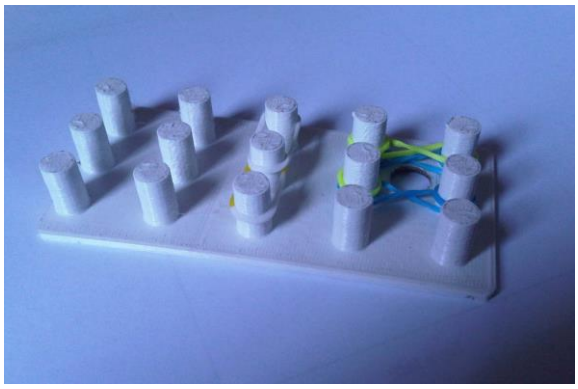
A key component of the loom is the hook tool, a small handheld implement with a hooked end, used to manipulate the rubber bands during the weaving process. The hook tool is often made from plastic, though it can also be made from metal for added strength. It allows users to lift and loop rubber bands over the pegs, creating the interwoven patterns that form the bracelet.

Some loom designs include additional connector pieces to link multiple bases together, enabling the creation of larger or more complex bracelets. These connectors are usually simple clips or snap-fit parts that join the loom sections securely without the need for additional tools.

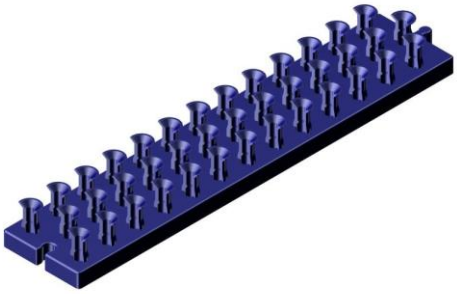
Customisation options are often available, with advanced designs featuring movable pegs that can be rearranged to create different patterns. Extensions and additional modules can be printed and attached to the main loom to expand its capabilities. Users can also print the loom and its components in different colours to make the process more visually intuitive and enjoyable.

Using a rubber band bracelet loom provides both educational and creative benefits. It helps improve fine motor skills, hand-eye coordination, and spatial awareness, making it a great educational tool for children. The loom also encourages creativity and experimentation, allowing users to design unique patterns and colour combinations for their bracelets.

Designed to be user-friendly, the loom is straightforward to use, with clear instructions often provided by the designer. Beginners can quickly learn to make basic bracelets, and the compact size makes it easy to carry around, so users can take their crafting projects on the go.



https://www.thingiverse.com/thing:376714



https://www.thingiverse.com/thing:818054

Figure 46. Rubber band bracelet looms examples

D.4.4 Bead loom for bracelets

A 3D printable bead loom for bracelets is a modern, customizable tool designed for crafting intricate and personalised beaded bracelets. This loom is compact and portable, allowing crafters to create beautiful beadwork with ease. The advantage of a 3D printable design is that it offers flexibility and customisation, making it possible to tailor the loom to specific project requirements and personal preferences.

Frame: At the core of the loom is the frame, which provides the main structure and support for the other components. The frame is typically rectangular and is designed to be sturdy yet lightweight, often printed from durable plastic materials like PLA or ABS. It features evenly spaced pegs or slots along the top and bottom edges. These pegs or slots are crucial for holding the warp threads in place. The spacing and configuration of these pegs can be customised through 3D printing, accommodating different bead sizes and design styles.

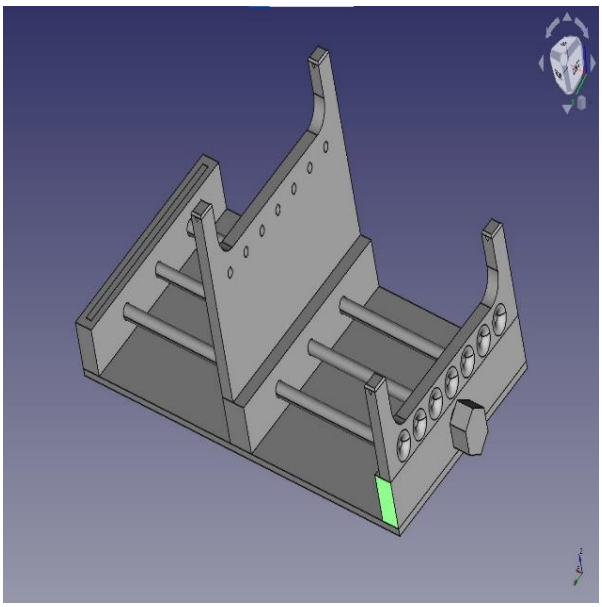
Pegs or Slots: These components are essential for maintaining the tension of the warp threads. The pegs or slots secure the threads, keeping them taut as beads are threaded onto them. This tension is key to creating consistent and even bead patterns. With a 3D printable loom, users can adjust the size and placement of the pegs or slots to fit various bead sizes and achieve different design effects.

Heddle Bar: The heddle bar is a movable part that separates the warp threads into two sets. This separation makes it easier to thread beads onto the weft thread (the horizontal thread) and helps keep the beadwork organised. The heddle bar can be precisely printed to fit the frame, allowing for smooth and efficient bead placement. This component is particularly useful for creating intricate bead designs and patterns.

Customisation and Printing: The 3D printable concept allows users to download and print loom designs from online repositories such as Thingiverse, MyMiniFactory, Cults3D, and PrusaPrinters. These platforms offer a range of loom designs that can be freely downloaded and customised. Once the STL files are obtained, they can be loaded into 3D printer slicing software, adjusted for print settings, and printed. The printed components are then assembled to create a functional bead loom tailored to individual needs.

Additional Tips: For those using traditional bead looms, it's important to set up warp threads properly to determine the length and width of the final bracelet. Looms that leave multiple warp threads at the ends may require backing with materials like Ultra Suede or ribbon for a polished finish. For specialised looms like the Ricks Beading Loom, which leaves fewer warp threads, finishing options may differ.

https://cults3d.com/en/3d-model/tool/beading-loom-200x50mm



https://cults3d.com/en/3d-model/tool/adjustable-length-bead-loom

Figure 47. Bead loom for bracelets examples

D.4.5 Pottery wheel

A 3D printable pottery wheel is an innovative tool designed for creating pottery, combining traditional crafting techniques with modern 3D printing technology. This wheel is compact, portable, and

customizable, making it an excellent choice for both novice and experienced potters. The primary advantage of a 3D printable pottery wheel is its flexibility and accessibility, allowing users to design and print a wheel that fits their specific needs and creative vision.

Base and Structure: The base of the pottery wheel provides the main support and stability. Typically, this base is designed to be sturdy yet lightweight, printed from durable materials like PLA or ABS. The base may include slots or mounts for attaching other components, such as the wheel head and the motor. Customizable through 3D printing, the base can be tailored to different sizes and shapes to suit the user's workspace and pottery projects.

Wheel Head: The wheel head is the rotating platform where the clay is shaped. In a 3D printable design, the wheel head is usually circular and designed to fit snugly onto the base. It features a flat, smooth surface to ensure even rotation and stability of the clay. The size and surface texture of the wheel head can be customised through 3D printing, allowing users to create a wheel head that suits their specific pottery techniques and project requirements.

Motor and Drive Mechanism: A key component of the pottery wheel is the motor, which provides the rotational force needed to shape the clay. In a 3D printable design, the motor and drive mechanism can be housed within the base or attached externally. The drive mechanism typically involves a belt or gear system that connects the motor to the wheel head. The design and specifications of the motor and drive mechanism can be customised to provide different speeds and torque levels, accommodating various pottery techniques and preferences.

Foot Pedal or Speed Control: To control the speed of the wheel head, a foot pedal or electronic speed control can be included in the design. This component allows the potter to adjust the wheel's speed while working, providing greater control over the shaping process. A 3D printable foot pedal can be customised for comfort and responsiveness, ensuring smooth and precise control over the wheel's rotation.

Splash Pan: A splash pan is an optional but useful component that surrounds the wheel head to catch excess water and clay. In a 3D printable design, the splash pan can be designed to fit snugly around the wheel head and base, preventing mess and making cleanup easier. The size and shape of the splash pan can be tailored to match the specific dimensions of the wheel head and base.

Customisation and Printing: The 3D printable concept allows users to download and print pottery wheel designs from various online repositories, such as Thingiverse, MyMiniFactory, Cults3D, and PrusaPrinters. These platforms offer a range of designs that can be freely downloaded and customised. Once the STL files are obtained, they can be loaded into 3D printer slicing software, adjusted for print settings, and printed. The printed components can then be assembled to create a fully functional pottery wheel.

This approach provides advantages in terms of accessibility and customisation. Users can experiment with different design elements, adjust the wheel to fit their workspace and tailor the components to their specific pottery techniques. This flexibility makes the 3D printable pottery wheel a valuable tool for both hobbyists and professional potters.

https://cults3d.com/en/3d-model/tool/mini-pottery-wheel

https://www.thingiverse.com/thing:3719662

Figure 48. Pottery wheel examples

D.4.6 3D printable pottery accessories

The integration of 3D printing technology with traditional pottery wheel accessories introduces a new realm of possibilities for potters. These 3D printed accessories, such as specialised forming patterns, enhance the pottery-making process by allowing artists to create intricate designs and textures on their clay creations while the wheel is in motion. This innovative approach combines the timeless art of pottery with the flexibility and precision of modern technology, catering to both novice and experienced potters.

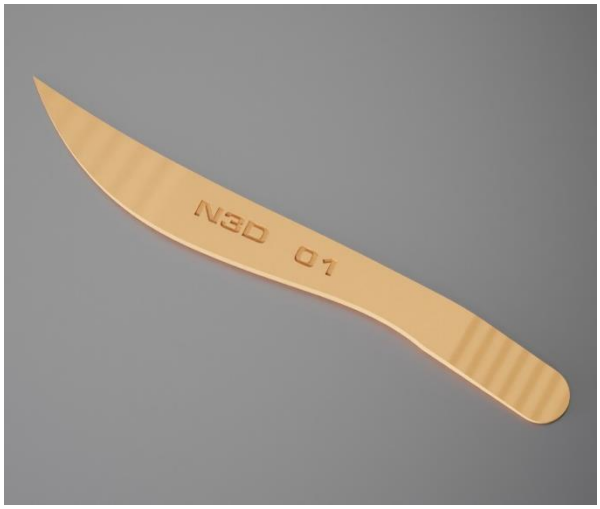
A primary advantage of 3D printed pottery wheel accessories is their customisation. Artists can design and print accessories that fit their specific needs and creative visions, from unique forming patterns to custom texturing tools. These accessories are made from durable materials like PLA or ABS, ensuring they withstand the rigours of pottery making while remaining lightweight and easy to handle.

The customisation extends to the size and shape of the accessories, allowing potters to tailor them to their workspace and specific projects. For instance, specialised forming patterns can be designed to create consistent, intricate designs on the clay as it rotates on the wheel. This capability transforms the traditional pottery wheel into a versatile tool that can produce a wide variety of artistic effects.

Accessibility is another benefit. Potters can download and print designs from online repositories such as Thingiverse, MyMiniFactory, Cults3D, and PrusaPrinters. These platforms offer a vast array of designs that can be freely downloaded, customised, and printed. Once the STL files are obtained, they can be adjusted using 3D printer slicing software and printed, allowing for the rapid creation and testing of new accessories.

This method of producing pottery wheel accessories is cost-effective, reducing the need for expensive, specialised tools. Potters can experiment with different designs without significant financial investment, encouraging innovation and creativity. The ability to print accessories on demand also eliminates the wait times associated with ordering and shipping traditional tools.

https://cults3d.com/en/3d-model/tool/pottery-tool-05



https://cults3d.com/en/3d-model/tool/pottery-tools-01

Figure 49. 3D printed pottery accessories examples

D.4.7 3D printable clay rolling stamps

A 3D printable clay rolling stamp is an innovative tool designed to add intricate textures and patterns to clay surfaces, enhancing the pottery and sculpting process. This tool is customizable, allowing artisans to create unique designs that can be applied to their clay projects. The primary advantage of a 3D printable clay rolling stamp is its flexibility and accessibility, enabling users to design and print stamps that fit their specific creative needs and artistic vision.

Design and Customisation: The design of a clay rolling stamp is essential to its function. Typically, the stamp consists of a cylindrical roller with a patterned surface. The pattern can be geometric, floral, abstract, or any design that the user desires. With 3D printing technology, these designs can be easily customised, allowing users to create unique and intricate patterns that might be difficult to achieve with traditional methods.

Roller: The roller is the main component of the clay rolling stamp. It is designed to be cylindrical, allowing it to roll smoothly over the clay surface, impressing the pattern into the clay. The roller can be printed from durable materials such as PLA or ABS to ensure longevity and consistent performance. The diameter and length of the roller can be adjusted through 3D printing to suit different project sizes and requirements.

Patterned Surface: The surface of the roller is where the design is engraved or raised. This patterned surface is what creates the texture of the clay. Using 3D modelling software, users can create intricate designs that are then translated into the roller surface. The depth and detail of the pattern can be finely tuned, allowing for a wide range of textures from subtle to highly detailed.

Handles: Handles are often included in the design of a clay rolling stamp to make it easier to use. These handles can be printed as part of the roller or attached separately. They provide a comfortable grip,

allowing the user to apply even pressure as they roll the stamp over the clay. The handles can be customised for ergonomic comfort, making the tool easier to use for extended periods.

Printing and Assembly: The 3D printable concept allows users to download or create their rolling stamp designs using 3D modelling software. Online repositories like Thingiverse, MyMiniFactory, Cults3D, and PrusaPrinters offer a variety of designs that can be freely downloaded and printed. Once the STL files are obtained, they can be loaded into 3D printer slicing software, adjusted for print settings, and printed. The printed components are then assembled, if necessary, to create a functional rolling stamp.

Application: To use the clay rolling stamp, the roller is pressed into the clay and rolled across the surface. The patterned surface impresses the design into the clay, creating a textured effect. This tool can be used on flat surfaces, cylindrical forms, or any shape of clay project. The ease of customisation means that users can create stamps specific to each project, allowing for a high degree of creativity and personalisation.

Benefits of 3D Printing: The 3D printable clay rolling stamp offers several benefits. It allows for intricate and unique designs that can be easily customised and reproduced. The ability to print multiple stamps with different patterns gives artisans a versatile toolkit for their projects. Additionally, the cost and time savings compared to traditional methods of creating custom stamps make 3D printing an attractive option for hobbyists and professionals alike.

Designs Exemplars

https://www.printables.com/model/163193-more-potteryclay-rolling-stamps

https://www.printables.com/model/97427-potteryclay-rolling-stamps-and-handle

Figure 50. 3D-printed clay stamps

The desk research in Section 5.1 provides a landscape view of how craft-related educational artefacts circulate in maker communities, and it identifies concrete "candidate designs" that can be fabricated with modest means. However, CRAEFT's contribution is not the catalogue itself, but the **translation of design availability into validated educational practice**: selecting representative candidates, adapting them for robustness and safety, and producing replicable learning material (instructions, demonstration media, and game/kit components). The following section, therefore, shifts from mapping the ecosystem to presenting the **CRAEFT use cases**, focusing on what was implemented, tested, and documented, and on how each artefact supports informal craft education.

Annex E: Weaving

E.1 Chair

An innovative and accessible way to create a loom is by repurposing a simple chair. This method utilises the legs of the chair as the foundational structure for the loom. To start, you securely mount the warp threads onto the legs, creating a stable and taut surface for weaving. The chair's design, with its four legs, allows for a balanced and symmetrical setup, making it easier to maintain tension across the threads. This setup is particularly beneficial for larger weaving projects, as the height and spacing of the chair legs provide ample room for creating broader and more intricate patterns. Moreover, using a chair as a loom is not only cost-effective but also a practical solution for those who may not have access to traditional weaving equipment. The chair's stability ensures a smooth weaving process, and its adjustable thread positioning offers design versatility.

E.2 Cardboard

For a more compact and portable weaving option, a loom can be crafted from a piece of cardboard and a couple of ice cream sticks. This method is perfect for small projects and for those new to weaving, offering an easy and inexpensive entry point into the craft. The cardboard serves as the base, with notches cut into the top and bottom to hold the warp threads in place. The ice cream sticks are then used to wrap and secure these threads, acting as anchors that keep the warp taut. This setup creates a mini loom that is both lightweight and easy to handle, making it ideal for weaving on the go or in limited spaces. The cardboard and ice cream stick loom is also highly customizable; you can adjust the size of the cardboard and the spacing of the notches to suit different project needs. This method encourages creativity and experimentation, allowing weavers to explore various patterns and techniques without the need for specialised tools.

E.3 Plate

Creating a round loom using a plastic plate is a weaving method for circular pattern designs. To make this loom, you start by cutting a plastic plate into the shape of a sunflower, with petals radiating out from the centre. Each 'petal' or triangle segment of the sunflower serves as a point to attach the warp threads. By tying the threads to the inner edges of each triangle, you create a radial warp structure that is perfect for weaving in a circular pattern. This method is particularly suited for coasters, mandalas, or decorative wall hangings. The plastic plate provides a sturdy base that can withstand the tension of the threads, ensuring a durable and stable loom. Additionally, the sunflower shape adds an aesthetic element to the loom, making weaving both functional and visually pleasing. This approach to loom-making is not only resourceful but also inspires creativity, as the round format opens up new possibilities for intricate and symmetrical designs.

E.4 Learning to Count

https://www.craeft.eu/elearning/course/view.php?id=8

This activity regards teaching basic enumeration concepts through paper weaving, combining creativity with learning. The activities aim to provide an enjoyable and interactive experience for students, complete with detailed instructions, required materials, and educational benefits.

Table 20. Activity Table: Learning to Count

Focus	Description	Materials	Benefits
Introduction	Discuss the concept of patterns, show examples (clothes, ceramics), and explain the repetition of designs and colours.	Everyday patterned objects	Awareness of patterns in daily life; recognition of repetition.
Preparation	Provide children with 2-3 coloured papers. Use rulers and pencils to cut strips of paper (1-2 cm wide).	Coloured papers, ruler, pencil, scissors	Develops fine motor skills; introduces measurement.
Creating the Base	Cut one sheet lengthwise into strips, leaving 2 cm intact at the top. Weave strips from other papers through base strips.	Coloured papers	Hands-on introduction to weaving; coordination.
Creating Patterns	Arrange strips in a specific order. Discuss repetition across the woven piece.	Prepared strips	Understanding sequence & repetition.
Symmetry & Repetition	Explain symmetry and apply it in woven designs. Create symmetrical patterns.	Coloured strips	Understanding symmetry and spatial reasoning.
Presentation & Discussion	Students present finished woven pieces. Group discussion on symmetry/asymmetry and repetition.	Completed woven pieces	Communication skills; reflection.
Advanced Patterns	Experiment with complex patterns (diagonal, zigzag). Combine multiple patterns in one piece.	Coloured strips, woven base	Creativity, problem-solving, and pattern recognition.
Recap & Conclusions	Recap concepts of patterns and symmetry; discuss how weaving aids in learning to count.	none	Consolidation of knowledge; linking craft to counting.

Annex F: eLearning tutorial - 3D printable designs

This annex is a practical "replication protocol" for educators, learners, and makers who wish to **locate, download, print, and assemble** 3D-printable designs from online communities in order to implement the physical craft activities described in this deliverable. It complements Section 5.1 (desk research) by focusing on **how to reproduce** selected designs reliably and responsibly (quality, safety, and licensing/attribution).

F.1. Communities of 3D printable designs

eLearning course: https://www.craeft.eu/elearning/course/view.php?id=152

Online repositories and maker communities act as distribution hubs for 3D-printable designs. They differ in curation level, documentation norms, and licence patterns, but they largely support the same workflow: **search → evaluate → download → print → assemble → iterate**.

Core communities referenced in this deliverable (non-exhaustive):

- **Thingiverse**, large, community-driven repository; breadth of content; variable documentation.
- **MyMiniFactory**, more curated and often "print-tested"; mixed free/paid content.
- **Cults3D**, mixed free/paid; strong independent designer presence; licence and access may vary.
- **Printables**, strong emphasis on documentation and practical print profiles; frequent "makes" and iteration feedback.

Additional communities you may encounter (optional sources): Pinshape, **GrabCAD** (engineering/CAD focus), **Thangs** (powerful search/aggregation and model visualisation).

Important note on freshness. Platform features, model availability, and licence terms can change. Always verify the current licence and download options on the day you reuse a design.

F.2 Locate and Print!

eLearning course: https://www.craeft.eu/elearning/course/view.php?id=153

This section provides a platform-agnostic procedure for locating and producing printable designs, with examples drawn from loom-related craft games (mini looms, weaving looms, potholder looms). The same procedure generalises to other categories in the deliverable.

F2.1 Using communities to locate physical loom games

Before you begin

- Stable internet connection.
- Access to a 3D printer (personal, institutional, or makerspace).
- A slicer (e.g., Cura or PrusaSlicer).
- Basic awareness of safe making when activities involve children (adult supervision, no small loose parts for young ages).

Step 1, Search with craft-relevant terms
Use a small set of precise keywords and iterate:

- *mini loom*, *weaving loom*, *potholder loom*, *bracelet loom*, *bead loom*
  Optionally add constraints:
- *print-in-place*, *no supports*, *easy print*, *for kids*, *educational*

Step 2, Triage candidates using "printability signals"
Prefer designs that include at least two of the following:

- photos of completed prints ("makes")
- user comments describing successful settings or common failures
- clear part list and/or assembly notes
- a provided print profile (common on Printables)
- designer notes about material choice, infill, and orientation

Step 3, Check licence and reuse conditions (non-negotiable)
Record the licence shown on the design page and confirm it is compatible with your intended use (educational use, workshops, potential dissemination). If unclear, treat it as **"do not redistribute"** until clarified.

Step 4, Download and organise files for traceability
Create a folder per design and store:

- STL/3MF files (and any assembly documentation)
- a screenshot or text copy of the design page showing **author + licence + URL**
- the date you accessed the file

Suggested metadata record (copy/paste into a note file)

- Design title:
- Author / creator handle:
- Platform:
- URL:
- Licence / terms:
- Date accessed:
- Files downloaded:
- Intended educational use (1–2 lines):
- Print material planned (e.g., PLA):
- Known risks (pins snapping, warping, small parts, etc.):

Step 5, Select one candidate for first fabrication
When several designs exist, start with the one that looks most robust and documented. Produce one print first, then iterate before printing multiple copies.

F2.2 Printing and assembly

Step 1, Import into slicer and set conservative defaults

- Material: **PLA** is generally recommended for educational handling due to ease of printing and dimensional stability.
- Orientation: follow designer guidance if provided; otherwise orient to minimise supports and maximise strength on load-bearing features.

Step 2, Strength and robustness settings (recommended starting point)
For educational tools (looms, frames, pegs) that will be handled repeatedly:

- Infill: medium-to-high (increase if pegs/pins are failing)
- Perimeters/walls: increase if thin features snap
- Layer height: moderate (prioritise strength and reliability over speed)
- Supports: only if necessary; avoid supports in tight mechanical areas unless instructed

Step 3, Print and perform a basic quality check

- Watch the first layers to confirm adhesion.
- Let the print cool before removal to avoid bending thin features.
- Remove supports carefully; inspect pins/pegs for micro-cracks.

Step 4, Assemble (dry-fit first)

- Dry-fit parts before using any adhesive.
- If the design uses snapping parts, do not force them; gently sand or reprint with slight adjustments if needed.

Step 5, Stabilise if the activity applies tension (loom-specific note)
Loom designs are often used under thread tension, which can deform thin frames or snap pins. If stability issues appear:

- mount the loom on a **rigid base** (e.g., a wooden panel), and/or
- reprint with increased strength settings (higher infill / more walls), and/or
- select a design variant with thicker pins or reinforced corners.

Step 6, Begin the craft activity (educational framing)
Once assembled:

- set up warp threads according to the design
- start weaving with simple patterns

- encourage exploration of tension and repeatability (what changes when yarn thickness or tension changes?)

Quick troubleshooting guide (print reliability)

- **Warping / bending:** increase bed adhesion, reduce drafts, consider a brim, and/or mount on a rigid base.
- **Pins/pegs snapping:** increase walls/perimeters and strength; inspect orientation; avoid prying parts off the bed.
- **Poor fit between parts:** check scale, tolerances, and material shrinkage; lightly sand; reprint if needed.
- **Overhang failures:** add supports only where necessary; adjust orientation.

Attribution checklist (recommended for educational reuse)

When you use a community design in a workshop or course hand-out, keep a minimal attribution record:

- Design title + author
- Platform + URL
- Licence
- Any modifications you made (e.g., “mounted on wooden base”; “strength settings increased”)

This keeps your educational practice aligned with openness, transparency, and respectful reuse.

Annex G: eLearning tutorial - Casting Soap Chess Pieces

G.1 English version - Casting Soap Chess Pieces with 3D-Printed Moulds

This tutorial demonstrates how to use 3D-printed moulds inspired by chess pieces to create your own soap chess set at home. The process requires only everyday tools, a few supplies, and patience.

E-Learning platform URL: https://www.craeft.eu/elearning/course/view.php?id=150

G.1.1 Materials

Table 21. List of materials and intended use

Material	Notes / Use
3D-printed chess moulds	For shaping the soap pieces
Soap base (100 g per batch)	Main material for each batch
Oil	Helps soap release from moulds
Soap colouring (1 drop per 100 g)	For tinting soap

Table 22. List of tools and intended use

Tool	Notes / Use
Kitchen scale	To measure the soap base accurately
Knife	To cut the soap base into smaller pieces
Coffee pot or small saucepan	For melting the soap base
Wooden chopstick or spoon	To stir the melted soap
Gas lighter (optional)	To remove surface bubbles or reheat
Rubber bands	To keep moulds tightly closed
Cotton swabs	For applying oil to moulds
Alcohol spray	Sprayed on the surface to prevent bubbles

Scissors or a knife	To trim excess soap after unmoulding

G.1.2 Instructions

Table 23. Instructions

Step 1. Prepare the moulds with oil

Apply a thin layer of oil inside the moulds using cotton swabs. This helps the soap pieces release smoothly once hardened.

Step 2. Melt the soap base carefully on low heat

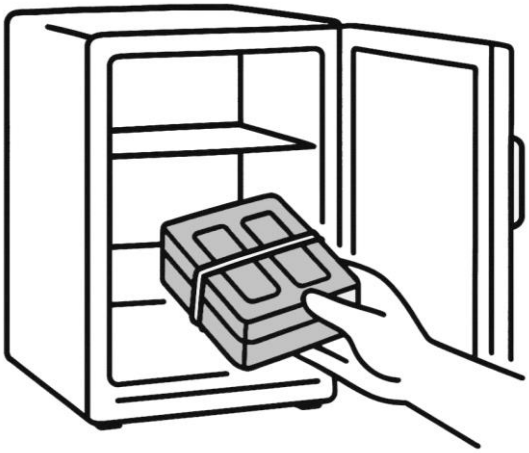
Cut 100 g of soap base and place it in a coffee pot. Heat gently over low flame, stirring constantly. Avoid high heat, which burns the soap and produces an unpleasant smell.

Step 3. Add colour

Once melted, add 1 drop of soap colouring per 100 g batch. Stir until the colour is evenly distributed.

Step 4. Cast the soap

Pour the melted soap into the prepared moulds. Secure the mould halves with rubber bands to prevent leaks. Lightly tap the moulds on the table to release trapped air bubbles. Spray alcohol on the surface to further minimise bubbles.

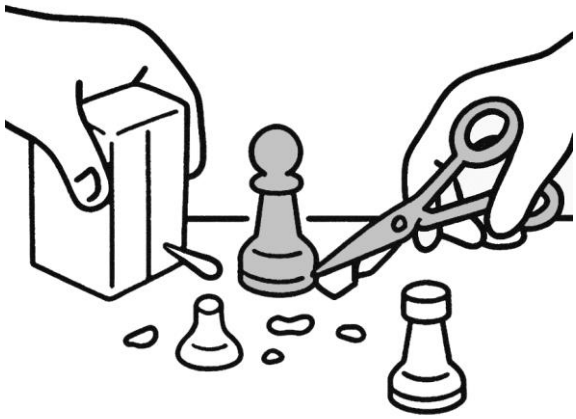


Step 5. Solidify (Wait)

Allow the soap to set. Wait until fully hardened.

Step 6. Unmould the finished pieces

Carefully remove the hardened soap pieces from the moulds. Trim away any excess material along the seams using scissors or a knife.



Learnings

- Soap pieces come out clean and detailed when temperature, oiling, and bubble control are well managed.
- Candle wax can also be used with the same process, opening possibilities for a full candle chessboard.
- Patience and low heat prevent burnt batches.
- Oiling moulds and spraying alcohol are crucial for quality results.

With practice, this process transforms digital 3D-printed designs into tangible, functional, and creative artefacts.

G.1.3 Maker Worksheet

Table 24. Maker worksheet

Materials	
1	3D-printed chess moulds
2	Soap base (100 g per batch)
3	Kitchen scale
4	Knife
5	Coffee pot or small saucepan
6	Wooden stick or spoon
7	Rubber bands
8	Oil + cotton swabs

9	Alcohol spray
10	Soap colouring (1 drop per 100 g)
11	Scissors/knife (for trimming)
12	Freezer (optional)

Table 25. Step Checklist

Step Checklist	
1. Prepare the moulds	
Brush oil inside the moulds with a cotton swab.	
Close moulds securely with rubber bands.	
2. Melt the soap base	
Cut 100 g of soap.	
Heat gently over a low flame.	
Stir constantly (don't boil).	
3. Add colour	
Add exactly 1 drop of colouring per 100 g.	
Stir until even.	
4. Cast the soap	
Pour melted soap into moulds.	
Tap moulds lightly on the table.	
Spray alcohol to remove bubbles.	
5. Cure	
Let the soap partially set.	
Store the moulds until they harden.	
6. Unmould & finish	
Remove hardened pieces carefully.	

Trim seams with scissors/knife.	

Table 26. Useful tips

Tips
Low heat = smooth soap.
Alcohol spray prevents bubbles.
Oiling moulds helps to easily release.
Freezer speeds curing.

G.1.4 Glossary

Table 27. Glossary of tools

Tool	**URL**	**Description**
Pressing machines	300430790	–
Melting pots	300417959	Heating equipment
Casting moulds	300422800	Shaping equipment. Forms into which liquid or molten substances are poured to take shape as they harden.

Table 28. Glossary of Materials

Material	URL	Description
Moulding material	300015153	Any material designed for or used to fill moulds.
Clay	300010439	–
Plasticine	300266336	A soft, plastic, non-drying, claylike substance, used for modelling.
Wax	300014585	–
Soap	300014329	–

Table 29. Glossary of actions

Action	**URL**	**Description**
Forming	300053098	Shaping, moulding, or fashioning into a certain state or condition.

Pressing	300053136	Forming by means of pressure, especially a steady, overall pressure.
Moulding	300053134	Giving form to something by use of a mould.
Nipping	300261403	Applying heavy pressure to something between two surfaces for a brief period. This is a subclass of pressing, but not entirely precise for our case.
Casting	300053104	Shaping by pouring a liquid or molten substance into a mould where it hardens.
Melting	300186835	–
Solidification	300380198	–
Filling	300053092	Inserting material into a hole, crack, or cavity.
Pouring	300250952	Causing a liquid, fluid, or anything in loose particles to flow or fall.
Drying	300053758	Making free or nearly free of liquids.

Table 30. Physical Entities

Entity	URL	Description
Energy	300056007	The capacity to do work. Any quantity with dimensions that can be represented as mass times length squared divided by time squared.
Force	300056017	Interaction that changes motion or causes deformation; agency or influence that, if applied to a free body, results chiefly in an acceleration of the body and sometimes in elastic deformation and other effects.
Pressure	300056048	Exertion of force per unit area.
Heat	300056020	Energy is transferred between a system and its surroundings as a result of temperature differences.

G.2 Greek version - Οδηγός Κατασκευής Σαπουνιών με Καλούπια 3D Εκτύπωσης

E-Learning platform URL: https://www.craeft.eu/elearning/course/view.php?id=151

G.2.1 Υλικά & Εργαλεία

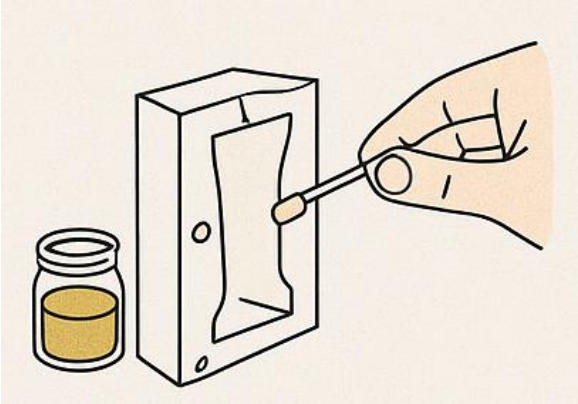
- Καλούπια (π.χ. από 3D εκτυπωτή – σχήματα σκάκι)
- Βάση σαπουνιού

- Ζυγαριά κουζίνας
- Μαχαίρι
- Μπρίκι
- Ξυλάκι ή κουτάλι
- Γκαζάκι ή εστία και αναπτήρας
- Λαστιχάκια (για να συγκρατούν τα καλούπια)
- Λάδι (για αντικολλητική ιδιότητα)
- Ποτηράκι & μπατονέτες (για το άλειμμα του λαδιού)
- Οινοπνευματώδης λοσιόν με ψεκαστήρα (για αποφυγή φυσαλίδων)
- Χρώμα (νερού ή ειδικό για σαπούνια)
- Ψαλιδάκι ή μαχαιράκι (για φινίρισμα)

G.2.2 Οδηγίες

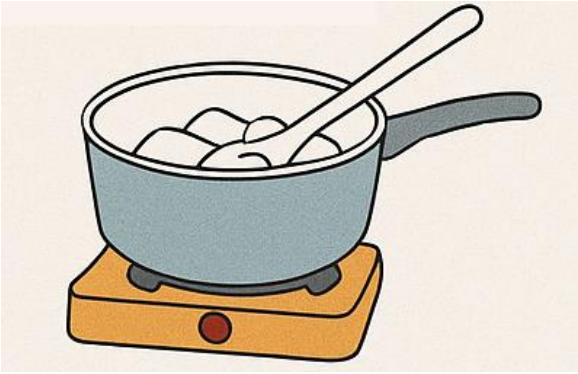
Βήμα 1: Προετοιμασία Καλουπιών

1. Πέρασε εσωτερικά τα καλούπια με λάδι χρησιμοποιώντας μπατονέτες.
2. Σφράγισέ τα καλά με λαστιχάκια για να μην ανοίξουν κατά τη χύτευση.



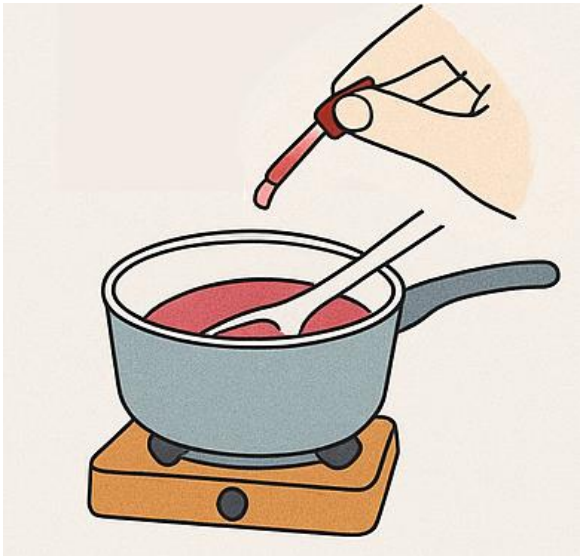
Βήμα 2: Λιώσιμο της Βάσης Σαπουνιού

1. Κόψε και ζύγισε ~100γρ βάσης σαπουνιού.
2. Ζέστανε σε χαμηλή φωτιά (προσοχή: όχι απευθείας φλόγα).
3. Ανακάτευε συνεχώς μέχρι να λιώσει απαλά και ομοιογενώς.



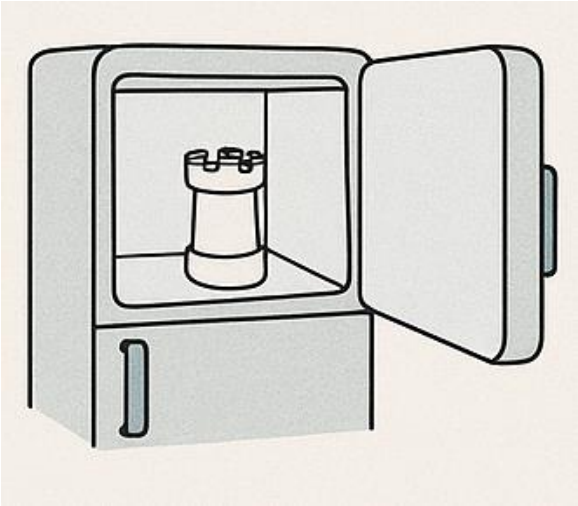
Βήμα 3: Χρωματισμός

1. Για κάθε 100γρ σαπουνιού, πρόσθεσε 1 σταγόνα χρώμα.
2. Ανακάτεψε καλά.



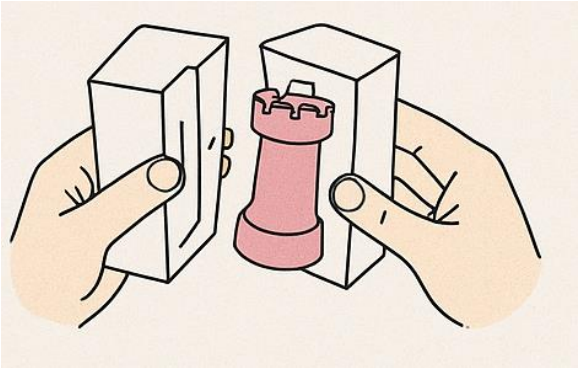
Βήμα 4: Έκχυση & Σταθεροποίηση

1. Ρίξε το υγρό σαπούνι στα καλούπια.
2. Ψέκασε με οινόπνευμα πριν και μετά την έκχυση για να εξαφανίσεις φυσαλίδες.
3. Χτύπα ελαφρά το καλούπι σε τραπέζι για να μην μεινουν τρύπες χωρίς σαπούνι μέσα στο καλούπι.



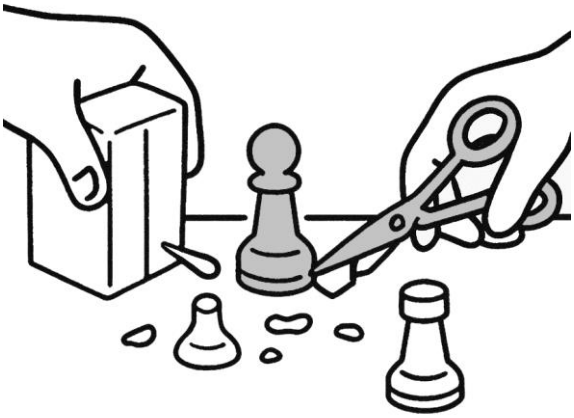
Βήμα 5: Πάγωμα & Ξεκαλούπωμα

1. Βάλε τα καλούπια στην κατάψυξη για γρήγορη σκλήρυνση.
2. Ξεκαλούπωσε προσεκτικά μόλις το σαπούνι σκληρύνει.



Βήμα 6: Φινίρισμα

1. Αφαίρεσε με μαχαιράκι ή ψαλιδάκι τις περιττές άκρες ή υπολείμματα.
2. Επαναλαμβάνεις μέχρι να ολοκληρώσεις όλα τα κομμάτια.



ANNEX H: Expanding a Tapestry into a Script

H.1 Facilities

H.1.1 Inventory of Entities

Scene and Objects

1. Swing with a wooden plank seat and ropes.
2. Stone fountain with sculpted basin.
3. Abundant foliage: trees, shrubs, flowers.
4. Possibly glimpses of distant architecture (a garden pavilion or wall).

Setting

- A pastoral garden or park, framed by trees and flowering shrubs.
- A stone fountain in the background, trickling water.
- A lawn or meadow foreground, scattered with flowers.
- Sky visible above; daylight, soft and balanced.

Mood

- Light, joyful, slightly flirtatious, a fête galante atmosphere, which is a typical Rococo theme of aristocratic leisure.
- A sense of movement from the swing, contrasting with still figures.
- The scene is both idyllic and theatrical; it feels posed, yet dynamic.

Character Set

Table 31. Claire

Claire	
Young woman on a swing.	
Role	Central figure, playful and carefree.
Motivation	Enjoys the thrill of the game, but also likes being the centre of attention.
Relationship	Childhood friend of Étienne, teasingly aware of his admiration.
Gesture	Light, airy, playful, the one in motion.
Expression	Joyful, carefree, lively, leaning back as the swing rises.

Posture	Lively, leaning back as the swing rises.
Costume	Wearing a flowing pale dress.
Dynamics	Seated on a rustic wooden swing, leaning back.

Table 32. Étienne

Étienne	
A young man is pushing the swing. Standing behind or beside the swing, one hand on the rope. Standing nearby, observing the game.	
Role	The active mover, driving the game forward.
Motivation	Wants to impress Claire, balancing playful bravado with subtle affection.
Relationship	Close friend of Claire, perhaps harbouring unspoken feelings.
Dynamics	Earnest, physical, slightly anxious underneath his smile.
Costume	Rococo costume, blue coat, waistcoat, slightly tousled from the effort.
Expression	Animated, focused on the swinging motion.
Gesture	Leaning slightly forward with effort.
Posture	Upright, hands either clasped or gesturing with amusement.
Expression	Smiling, playful.

Table 33. Margot

Margot	
Young woman as companion/onlooker. Standing a short distance from the swing, slightly turned toward the central action.	
Role	The amused onlooker, voice of commentary.
Motivation	Enjoys teasing both Claire and Étienne, likes stirring tension for fun.
Relationship	Friend to both, confidante of Claire, perhaps suspecting Étienne's feelings.
Dynamics	Witty, observant, adding commentary that nudges the others.
Costume	Rococo gown with light-coloured fabric and ornamentation.
Posture	Upright stance, hands gesturing lightly.

Expression	Gentle amusement, with a warm smile, as though entertained by the playful scene. Composed yet engaged, suggesting both elegance and attentiveness.
Gesture	Hands clasped lightly at the waist or one hand raised in a soft, conversational motion, reinforcing her role as an observing participant rather than an active one.

Story Arc

Table 34. (3-beats): 1. Visual rhythm: movement of swing → sudden interruption → calm resolution, 2. Character rhythm: carefree Claire → anxious Étienne → mischievous Margot, 3. Narrative rhythm: playful → complication → harmony restored, but changed.

Beat 1, Setup (Joyful Swing)
• Claire is already mid-swing, laughing as Étienne pushes her higher. • Étienne shows off a little, putting more strength into the push. • Margot stands aside, teasing them both with witty remarks. • Mood: light, playful, idyllic.
Beat 2, Complication (Something Goes Wrong)
• The swing lurches too far, Claire nearly loses her shoe or hat. • Claire either gasps in surprise or laughs nervously. • Margot seizes the chance to tease Étienne, adding pressure. • Tension: playful scene now charged with risk, embarrassment, or revelation.
Beat 3, Resolution (Return to Harmony)
• The moment of tension passes, the swing steadies, Claire recovers, and laughter resumes. • But a new tone lingers: perhaps a glance between Claire and Étienne, or Margot's knowing smile. • The tableau 'freezes' again, echoing the tapestry's idyllic stillness, but now layered with subtext.

H.1.2 Theatrical Script

Table 35. Theatrical Script

(Claire swings, laughter filling the air. Étienne pushes gently, then with more force. Margot stands with folded arms, watching amused.)
Claire: Higher, Étienne! The sky is mine today.

Étienne (smiling, pushing harder): Careful, or you'll fly clear into the fountain. Margot (teasing): And who would fetch her then? Not you, Étienne—you'd dive in headfirst.
(Claire throws her head back, hair catching the light. The swing rises sharply. A shoe slips loose and dangles precariously.)
Claire: Oh! My slipper—!
(She steadies herself, clutching the ropes. Étienne freezes, hand still on the rope, suddenly concerned. Margot claps her hands and laughs.)
Margot: Look at our gallant knight, struck pale by a slipper! You guard her as if she were porcelain. Étienne (flustered): It's nothing—just a slip. Hold tight, Claire. Claire (grinning, regaining composure): A slip indeed. But what is a garden without a little mischief?
(The swing slows. Claire looks toward Étienne with a playful glance; he avoids her eyes. Margot catches it and smirks knowingly.)
Margot: Ah, the air grows heavy with secrets. Shall we call it a day before hearts swing higher than ropes?
(Claire hops lightly off the swing. She and Étienne exchange a brief, wordless glance before laughter resumes. The three walk together toward the fountain, their voices blending with the garden sounds.)
Curtain.

H.1.3 Graphic Novel

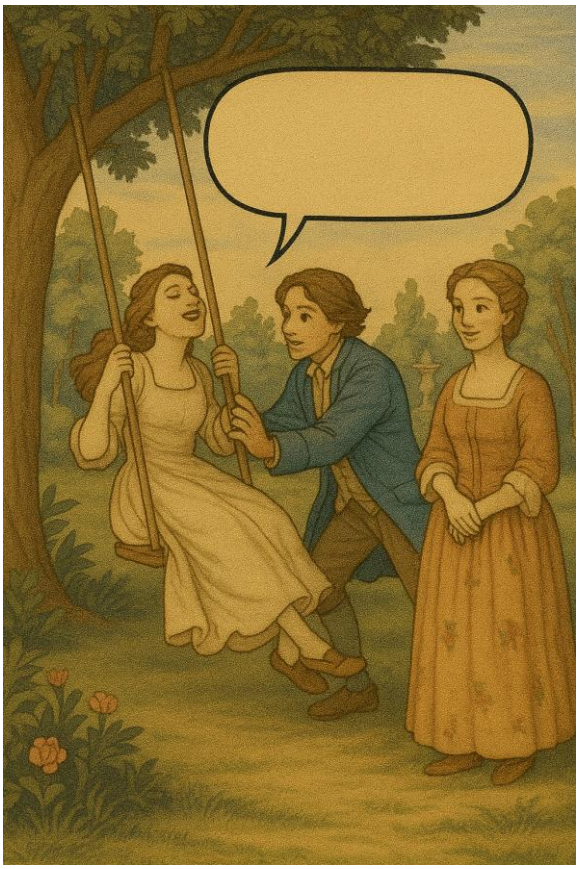
Table 36. Graphic Novel

Panel 1 (Wide Establishing Shot)

Scene: Garden with trees and a fountain. Claire swings, hair flowing. Étienne pushes behind. Margot stands to the side, arms folded, smiling.

Caption: 'A summer afternoon in the garden…'

Panel 2 (Medium Shot, Swing in Motion)



Claire is leaning back joyfully on the swing, eyes closed in laughter.

Étienne pushes with more effort, expression proud but nervous.

Margot, smaller in background, smirking.

Panel 3 (Close-Up, Claire's Slipper)

The swing reaches high; Claire's shoe dangles, about to fall.

Her expression shifts to alarm.

Étienne's face was visible behind, suddenly concerned.

Panel 4 (Medium Shot, Margot Teases)

Margot claps her hands, laughing.

Claire clutches the ropes, steadying herself.

Étienne froze mid-motion, startled.

Panel 5 (Close-Up, Étienne Flustered)

Étienne is leaning forward, one hand on the rope, with a worried expression.

Claire turned her head toward him, half smiling despite the scare.

Panel 6 (Intimate Shot, The Glance)

The swing slows. Claire and Étienne exchange a subtle glance.

Margot is in the background, noticing and smirking knowingly.

Panel 7 (Wide Closing Tableau)

Claire steps off the swing gracefully.

Étienne stands beside her, slightly awkward.

Margot joins them, still amused.

All three walk toward the fountain together.

Caption: 'And laughter returns to the garden…'

H.1.4 Cinematographic Production Scripts

Script

Table 37. Script

EXT. ROCOCO GARDEN – DAY A sunlit Rococo Garden. Trees and flowering shrubs frame a lawn. A stone fountain trickles in the background. A rustic wooden swing hangs from a branch. CLAIRE swings joyfully, her pale dress flowing. ÉTIENNE stands behind, pushing with effort. MARGOT watches from the side, amused.
CLAIRE (happily, shouting over the motion) Higher, Étienne! The sky is mine today! ÉTIENNE (smiling, breath quickening as he pushes) Careful, or you'll fly clear into the fountain. MARGOT (teasing, folding her arms) And who would fetch her then? Not you, Étienne—you'd dive in headfirst. The swing arcs higher. CLAIRE throws her head back, laughter ringing. Her hair catches the light. Suddenly, a slipper slips loose, dangling precariously from her foot. CLAIRE (startled) Oh! My slipper—! She clutches the ropes to steady herself. ÉTIENNE freezes mid-motion, his face shifting from bravado to concern. MARGOT claps her hands in delight. MARGOT (laughing, sharp) Look at our gallant knight, struck pale by a slipper! You guard her as if she were porcelain. ÉTIENNE (flustered, defensive) It's nothing—just a slip. Hold tight, Claire. CLAIRE (grinning, regaining composure) A slip indeed. But what is a garden without a little mischief? The swing slows. A silence lingers. CLAIRE and ÉTIENNE exchange a quick, loaded glance. He looks away. MARGOT notices and smirks knowingly.

MARGOT (dryly, with a smile) Ah, the air grows heavy with secrets. Shall we call it a day before hearts swing higher than ropes? CLAIRE hops lightly from the swing. For a moment, she and ÉTIENNE face each other, wordless. Then laughter returns. The three walk together toward the fountain, voices blending with the sound of water. FADE OUT.
Notes • Lighting: Warm late-afternoon tones, golden-hour softness. • Camera motion: Gentle tracking and pans to mimic the swing's rhythm. • Pacing: Gradual build from playful energy → brief tension → soft resolution. • Soundscape: Natural birdsong, water fountain, creaking ropes, laughter.

Shot List

Table 38. Shot List

Scene 1 – Establishing the Garden
1. Wide establishing shot – A Rococo Garden with trees, a fountain, and a swing in frame. CLAIRE is already swinging, ÉTIENNE behind, MARGOT at the side. Sunlight glows through foliage. 2. Tracking wide shot – Camera glides sideways as the swing arcs forward, following CLAIRE's movement.
Scene 2 – Joy and Teasing
1. Medium shot (front of swing) – CLAIRE leans back, laughing, hair flowing. Background blurred to emphasise joy. 2. Medium shot (behind swing) – ÉTIENNE pushes with effort, his expression shifting between pride and nerves. 3. Medium shot (static) – MARGOT folds her arms, smirking. She tilts her head as she teases.
Scene 3 – The Slipper
1. Insert close-up – CLAIRE's slipper dangling at the edge of her toes. Sunlight glints off the shoe. 2. Close-up – CLAIRE's face shifts from laughter to alarm. 3. Close-up – ÉTIENNE freezes mid-motion, eyes widening. 4. Medium shot – MARGOT claps her hands in laughter, her dress catching the light.

Scene 4 – The Pause
1. Medium two-shot (CLAIRE & ÉTIENNE) – The swing slows. CLAIRE steadies herself, ÉTIENNE hovers awkwardly. 2. Close-up – The ropes of the swing creak to a stop. 3. Close-up (reaction) – MARGOT smiles knowingly, watching.
Scene 5 – The Glance
1. Medium close-up (CLAIRE & ÉTIENNE) – Their eyes meet for a fraction of a second, a quiet intimacy. 2. Over-the-shoulder shot (from CLAIRE's perspective) – ÉTIENNE averts his gaze, conflicted. 3. Over-the-shoulder shot (from ÉTIENNE's perspective) – CLAIRE smiles faintly, still composed.
Scene 6 – Resolution
1. Wide shot – CLAIRE hops lightly off the swing, the fountain visible in the distance. 2. Medium three-shot – The trio stand close together, smiling with softened expressions. 3. Wide closing shot – They walk toward the fountain, laughter blending with the water's sound. The camera holds steady until they exit the frame.

Storyboard

Table 39. Storyboard

Storyboard

Video Generation Prompts

Table 40. Video Generation Prompts

Panel 1 – Establishing Scene
A Rococo-style Aubusson tapestry scene, garden with trees and a fountain. Claire, in a white dress, swings forward, Étienne, in a blue coat, pushes gently behind her, Margot, in an orange dress, stands smiling nearby. Muted Rococo colours, woven tapestry texture. Gentle motion as Claire rises on the swing, her hair flowing slightly.
Use your Panel 1 image as a reference. Animate a slow forward swing motion.
Panel 2 – Swing in Motion
Aubusson tapestry scene, same characters. Claire leans back joyfully on the swing, eyes closed in laughter. Étienne pushes harder, looking proud but nervous. Margot, in the background, smirks knowingly. Subtle tapestry weave texture. The swing moves higher, Claire's dress and hair flowing with motion.
Use Panel 2 image. Animate upward motion of the swing with gentle fabric flow.

Panel 3 – Claire's Slipper
Aubusson tapestry in the Rococo Garden. Claire, on the swing, looks alarmed as her shoe dangles, about to fall. Étienne, behind her, suddenly looks concerned. Woven tapestry texture, muted colours. Animate the slipper wobbling and almost slipping off as Claire steadies herself.
Use Panel 3 image. Animate shoe dangling + facial reactions.
Panel 4 – Margot Teases
Aubusson tapestry-style scene, garden setting. Claire, on the swing in a white dress, clutches the swing ropes, steadying herself. Étienne freezes mid-motion, startled. Margot, in an orange dress, claps her hands, laughing. Muted Rococo colours, tapestry weave visible. Animate Margot's clapping and Étienne's pause.
Use Panel 4 image. Animate Margot's hands + slight startled reaction from Étienne.
Panel 5 – Breaking the Moment
Aubusson tapestry-style illustration. Claire pauses mid-motion on the swing, still holding the ropes. Étienne glances aside nervously. Margot looks amused. Muted Rococo palette, woven texture. Animate Claire swaying slightly as if the swing slows down, while Étienne shifts awkwardly.
Use Panel 5 image. Animate slight swing slowdown + body language.
Panel 6 – Subtle Glance
Rococo Aubusson tapestry, pastoral garden with fountain. The swing slows. Claire and Étienne exchange a subtle glance, almost shy. Margot, in the background, notices and smirks knowingly. Muted Rococo tones, woven tapestry effect. Animate a slight tilt of Claire's and Étienne's heads as their eyes meet.
Use Panel 6 image. Animate gentle head/eye movement.
Panel 7 – Closing Group Scene
Aubusson tapestry scene in Rococo style, garden background with fountain. All three figures now stand together, smiling warmly. Claire in white, Étienne in blue, Margot in orange. Woven tapestry texture, muted Rococo colours. Animate them standing close in a group portrait-style pose, with small natural movements, like hands or heads adjusting slightly.
Use Panel 7 image (rectangular edit). Animate slight group movement, like a portrait coming alive.

H.2 Activity

This building is inscrit au titre des monuments historiques de la France. It is indexed in the base Mérimée, a database of architectural heritage maintained by the French Ministry of Culture, under the reference Château de Losmonerie.

H.2.1 Objective

To learn how to transform a **visual narrative** (an Aubusson tapestry scene) into a **short dramatic story**, and then explore how the same story can be adapted into different creative media (play, film, graphic novel).

H.2.2 Activity Description

Step 1. Observation (10–15 min)

- Present the chosen tapestry (*Pastoral Scene: Blind Man's Buff*).
- Ask learners to **look closely**:
  - Who is in the scene?
  - What are they doing?
  - What objects, animals, or buildings are visible?
  - What is the mood (playful, serious, tense)?
- Write down at least **5 visual details** and **3 questions** about what might be happening.

Step 2. Imagining Before and After (15–20 min)

- Ask: *What happened just before this moment?*
- Ask: *What might happen immediately after?*
- Learners sketch a **two-sentence mini-story** (before + after).

Step 3. Character Building (20 min)

- Assign simple names to 2–4 figures in the tapestry.
- Give each one:
  - A **motivation** (e.g., 'Lucille wants to win the game,' 'Henri hides a secret').
  - A **relationship** (friend, admirer, rival).
- Encourage short written notes, no more than 2–3 lines per character.

Step 4. Script Expansion (30–40 min)

- Draft a **short scene** (half a page to 1 page).
- Include:
  - Dialogue (at least 5–6 exchanges).
  - One moment of **tension** (a near-capture, a revelation, a comic mishap).
  - A **resolution** (comic, romantic, or ironic).
- This becomes the **core script**, adaptable to any medium.

Step 5. Medium Adaptation (40 min)

Split learners into three groups (or let them choose one medium):

1. **Theatrical Play**
   a. Add stage directions.
   b. Decide where actors stand and move.

   c. Perform a short reading.
2. **Graphic Novel Page**
   a. Break the script into 5–7 panels.
   b. Sketch rough frames (stick figures, fine).
   c. Add dialogue balloons and captions.
3. **Film Scene**
   a. Storyboard 6–7 shots.
   b. Decide on camera angles (wide, close-up, tracking).
   c. Add notes on sound (music, silence, ambient).

Step 6. Sharing & Reflection (20 min)

- Each group presents their version.
- Discuss:
  - How does the **medium change the story**?
  - What gets added or lost in each adaptation?
  - Which version feels closest to the tapestry's spirit? Which feels most different?

Outcome

By the end, learners will:

- Understand how to 'read' a tapestry narratively.
- Create a short script inspired by material culture.
- Explore how the **same story transforms** across theatre, film, and graphic novel.

H.2.3 Materials

Printouts or a projection of the chosen tapestry.

Paper & pens for notes and sketches.

Optional: coloured pencils for comic layouts.

Space for reading/performance.

Storytelling Worksheet

Expanding a Tapestry into a Script

Chosen Tapestry: Aubusson *Pastoral Scene (Blind Man's Buff, 18th c.)*

Step 1. Observation (Look Closely)

Instructions: Study the tapestry carefully. Write down what you see.

- Who is in the scene?
  - _____
  - _____
  - _____
- What are they doing?
  - _____
- What objects/animals/buildings are visible?
  - _____
- What is the mood (playful, serious, tense)?
  - _____

Step 2. Imagine Before and After

Question 1: What might have happened *just before* this moment?
→ _____

Question 2: What might happen *just after* this moment?
→ _____

Step 3. Character Building

Give names and traits to 2–4 figures:

Character	Motivation (what they want)	Relationship (to others)
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____

Step 4. Script Expansion

Write a short scene (½–1 page). Include:

- Dialogue (at least 5–6 exchanges).
- A moment of tension (a near-capture, a secret, or a mishap).
- A resolution (comic, romantic, or ironic).

(Space to draft)

Step 5. Medium Adaptation

Choose one path (or do all):

1. **Theatre**, Add stage directions. Where do the characters stand? How do they move?
    - Notes: _____
2. **Graphic Novel**, Break your story into 5–7 panels. Sketch boxes and add speech bubbles.
    - Panel Sketches: (draw boxes below)
      [ ] [ ] [ ] [ ] [ ] [ ] [ ]
3. **Film**, Plan 6–7 shots. Decide camera angles (wide, close-up, tracking) and sound cues.
    - Shot Notes: _____

Step 6. Reflection

- What was easy? _____
- What was challenging? _____
- Which version (theatre, comic, film) felt closest to the tapestry? _____
- Which version changed it the most? _____

H.2.4 Debate

A debate activity is a strong way to combine critical thinking, historical context, and ethical awareness.

Interpreting Historical Imagery in Cultural Heritage

Topic: Should reconstructions of Rococo/Aubusson tapestry imagery preserve historical biases (gender inequality, racism, stereotypes) for accuracy, or should they be filtered to avoid oversexualisation and reinforce ethical values today?

Roles & Positions

Team A: Ethical Safeguards
Position: Reconstructions should curate training sets and constrain outputs to prevent oversexualisation, stereotype reinforcement, and voyeuristic portrayals.
Arguments: Modern audiences interpret images differently from 18th-century viewers. Cultural heritage projects have a responsibility to avoid harmful or misleading representations. Training sets reproduce biases; therefore, creators must filter with intention. Grace, atmosphere, and textile fidelity are valid, authentic features without amplifying historical prejudices.
Team B: Historical Realism
Position: Reconstructions should show inequalities, racism, and stereotypes as they were, because these are historical facts that shaped the art.
Arguments: • Omitting these elements risks whitewashing history. • Historical authenticity requires acknowledging uncomfortable truths. • Recreating the full context stimulates critical reflection. • Viewers should be trusted to engage critically when guided properly.

Debate Structure

1. Introduction (5 minutes)
• Moderator introduces the tapestry scene (garden swing, Rococo context).

• Frame the question: 'When we reconstruct historical imagery, what matters more—accuracy to the biases of the past, or ethical safeguards for the present?'
2. Team Statements (5 minutes each)
• Team A outlines the need for ethical safeguards in training sets and outputs. • Team B argues for preserving inequality and stereotypes as historical truth.
3. Rebuttals (3 minutes each)
• Each team challenges the other: • A → 'Depicting inequality risks normalising it.' • B → 'Censoring inequality erases history.'
4. Open Floor (10 minutes)

• Participants pose questions across teams.
• Moderator injects guiding prompts:
• 'What happens if a child encounters these images online?'
  ○ 'Is a reconstruction an artwork, a document, or both?'
  ○ 'How do we distinguish between portraying and endorsing inequality?'

5. Reflection & Conclusion (10 minutes)
Moderator leads a synthesis: Both sides are valid: accuracy preserves scientific objectivity; safeguards preserve ethical responsibility. • A balanced approach is needed: portray biases but contextualise them clearly, guiding the viewer toward critical understanding. • Group writes a joint Code of Practice Statement (one or two sentences).

Learning Outcomes

By the end of the activity, participants will:

- Recognise how training sets and generation methods influence cultural heritage reconstructions.
- Understand the ethical tension between objectivity (showing historical reality) and responsibility (avoiding harmful stereotypes).
- Practise framing critical discussions on cultural heritage presentation.
- Draft actionable principles for balancing scientific accuracy with ethical interpretation.

Facilitator's Material

Team A: Ethical Safeguards

Opening Statement (approx. 3 minutes)
We believe that reconstructions of Rococo tapestry imagery must prioritise ethical safeguards. When training sets are built, they inherit the biases of the past, gender inequality, oversexualisation, and even racism. If left unchecked, machine learning models amplify these biases, exaggerating features or stereotypes far beyond their historical context. Our role as creators is not simply to reproduce the past but to interpret it responsibly. A tapestry may once have included playful eroticism, but when seen today through modern digital media, this can appear voyeuristic or objectifying. If we uncritically reproduce such images, we risk misleading audiences or reinforcing harmful stereotypes. Instead, we should highlight the authentic features that truly define Rococo style: elegance of line, pastel colours, textile detail, and atmosphere of grace. By carefully curating training sets, by constraining outputs, and by reviewing results critically, we preserve cultural heritage without amplifying its prejudices. This is not censorship, it is responsible stewardship of history.

Team B: Historical Realism

Opening Statement (approx. 3 minutes)
We argue that reconstructions should reflect the full historical reality, including its inequalities and prejudices. Rococo art emerged in a society where gender roles were rigid, where women were often portrayed as objects of desire, and where colonial trade and racism underpinned cultural production. To remove these elements in reconstruction is to erase history. A reconstruction is not only an artwork, it is also a document. If we filter out sexism or racism for fear of offending, we risk creating a sanitised past that never existed. Historical imagery should confront us with the uncomfortable truths of its time. Only then can audiences understand the evolution of culture, reflect on injustice, and compare it to the present. Yes, biases exist in the training sets. But rather than excluding them, we should contextualise them. A realistic portrayal that exposes these unfortunate elements provides a chance to teach critically: to ask why inequality was normalised then, and what lessons it holds for us now.

Moderator's Synthesis

Closing Statement (5 minutes)
Thank you to both teams for presenting compelling arguments.

We have heard Team A warn us of the risks of oversexualisation and stereotype amplification when working with training sets. They emphasised the responsibility of creators to safeguard audiences, ensuring that cultural heritage is presented with care and without reinforcing harmful imagery.

On the other hand, Team B reminded us that Rococo art emerged from an unequal society, and that those inequalities are part of its historical truth. They argued that to remove them entirely would be to whitewash the past, depriving audiences of the opportunity to confront uncomfortable realities and to think critically about history.

Both positions are valid, and together they highlight the central challenge of cultural heritage reconstruction: balancing scientific objectivity with ethical responsibility.

The way forward is not to choose one side exclusively, but to integrate both. Reconstructions should:

- Acknowledge inequalities and biases when they were historically present.
- Contextualise them clearly, so that viewers understand these were features of the past, not values we endorse today.
- Avoid exaggeration by curating training sets and reviewing outputs carefully, ensuring that historical realities are portrayed but not sensationalised.

This debate shows us that cultural heritage is not just about reproducing images, it is about interpreting history responsibly. We must aim for representations that are faithful to their time, but which also invite reflection, critique, and ethical awareness.

Code of Practice (to be written jointly by the group)

'Reconstructions of cultural heritage should be both historically accurate and ethically responsible. They must portray inequalities and biases of the past with honesty, but contextualise them carefully to prevent misinterpretation or reinforcement of stereotypes. Accuracy without context risks harm; context without accuracy risks erasure. Balanced representation achieves both truth and care.'

References

1. De Gloria, A., Bellotti, F., & Berta, R. (2014). Serious games for education and training. International Journal of Serious Games, 1(1). doi: 10.17083/ijsg.v1i1.11
2. Wattanasoontorn, V., Boada, I., García, R., & Sbert, M. (2013). Serious games for health. Entertainment Computing, 4(4), 231–247. doi: 10.1016/j.entcom.2013.09.002
3. Klimmt, C. (2009). Serious games and social change: Why they (should) work. In U. Ritterfeld, M. Cody, & P. Vorderer (Eds.), Serious games: Mechanisms and effects (pp. 248–270). Routledge.
4. Yu, Z. (2019). A meta-analysis of use of serious games in education over a decade. International Journal of Computer Games Technology, 2019, 4797032. doi: 10.1155/2019/4797032.
5. Wang, R., DeMaria Jr, S., Goldberg, A., & Katz, D. (2016). A systematic review of serious games in training health care professionals. Simulation in Healthcare, 11(1), 41–51. doi: 10.1097/SIH.0000000000000118
6. Susi, T., Johannesson, M., & Backlund, P. (2007). Serious games: An overview, Technical Report HS-IKI-TR-07-001, University of Skövde. https://www.diva-portal.org/smash/get/diva2:2416/FULLTEXT01.pdf
7. Hookham, G., & Nesbitt, K. (2019). A systematic review of the definition and measurement of engagement in serious games. In Proceedings of the Australasian Computer Science Week Multiconference (pp. 1–10). Association for Computing Machinery. doi: 10.1145/3290688.3290747
8. Ritterfeld, U., Shen, C., Wang, H., Nocera, L., & Wong, W. L. (2009). Multimodality and interactivity: Connecting properties of serious games with educational outcomes. Cyberpsychology & Behaviour, 12(6), 691-697.
9. Gouveia, D., Lopes, D., & De Carvalho, C. V. (2011). Serious gaming for experiential learning. Frontiers in Education Conference (FIE) (pp. T2G-1). IEEE. doi: 10.1109/FIE.2011.6142778
10. Johnson, C. I., Bailey, S. K., & Van Buskirk, W. L. (2017). Designing effective feedback messages in serious games and simulations: A research review. In P. Wouters & H. van Oostendorp (Eds.), Instructional techniques to facilitate learning and motivation of serious games (pp. 119–140). Springer. doi: 10.1007/978-3-319-39298-1_7
11. Fonseca, X., Slingerland, G., Lukosch, S., & Brazier, F. (2021). Designing for meaningful social interaction in digital serious games. Entertainment Computing, 36, 100385. doi: 10.1016/j.entcom.2020.100385
12. Sousa, M., Oliveira, A. P., Cardoso, P., Zagalo, N., & Vairinhos, M. (2021). Defining the mechanisms for engagement design protocol towards the development of analogue and hybrid serious games: Learning from FlavourGame. In Joint International Conference on Serious Games (pp. 31–46). Springer. doi: 10.1007/978-3-030-88272-3_3
13. Wu, R., Zhang, J. X., Leaf, J., Hua, X., Qu, A., Harvey, C., Holtzman, E., Ko, J., Hagan, B., James, D., Guimbretière, F., & Marschner, S. (2020). Weavecraft: An interactive design and simulation tool for 3D weaving. ACM Transactions on Graphics, 39(6), Article 210. doi: 10.1145/3414685.3417865
14. Zirawaga, V. S., Olusanya, A. I., & Maduku, T. (2017). Gaming in education: Using games as a support tool to teach history. Journal of Education and Practice, 8(15), 55–64.
15. Lin, C. H., & Chen, C. M. (2016). Developing spatial visualisation and mental rotation with a digital puzzle game at the primary school level. Computers in Human Behaviour, 57, 23–30. doi: 10.1016/j.chb.2015.12.026
16. Bhaduri, S., Ortiz Tovar, J. G., & Kane, S. K. (2017). Fabrication games: Using 3D printers to explore new interactions for tabletop games. In Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition (pp. 51–62). Association for Computing Machinery. doi: 10.1145/3059454.3059463.

17. De Souza e Silva, A. (2006). From cyber to hybrid: Mobile technologies as interfaces of hybrid spaces. Space and Culture, 9(3), 261–278. doi: 10.1177/1206331206289022
18. Sakamoto, M., Nakajima, T., & Alexandrova, T. (2012). Digital-physical hybrid design: Harmonising the real world and the virtual world. In Proceedings of the 7th International Conference on Design and Semantics of Form and Movement (DesForm 2012) (pp. 211–214).
19. DeepMind. (2018). AlphaZero: Shedding new light on chess, shogi, and Go. DeepMind. https://deepmind.google/discover/blog/alphazero-shedding-new-light-chess-shogi-and-go/
20. Education Week. (2022, July 14). How chess is making a comeback in schools. https://www.edweek.org/teaching-learning/how-chess-is-making-a-comeback-in-schools/2022/07
21. FIDE. (2025). FIDE: The International Chess Federation. https://www.fide.com
22. House of Staunton. (2025). Chess sets and equipment. https://www.houseofstaunton.com
23. Jaques of London. (2025). Luxury chess sets. https://www.jaqueslondon.co.uk
24. Millennium Chess. (2024). Electronic chess boards. https://www.millenniumchess.com
25. NPD Group. (2021). Toy industry sales data. NPD.
26. Similarweb. (2025). Lichess.org traffic data. https://www.similarweb.com/website/lichess.org/
27. Statista. (2022). The board games market worldwide. https://www.statista.com
28. Statista. (2023). Board game consumers by age group. https://www.statista.com
29. StreamsCharts. (2025). Hikaru Nakamura Twitch statistics. https://streamscharts.com/channels/hikaru
30. TechCrunch. (2025, January 16). Chess.com passes 200 million members. https://techcrunch.com/2025/01/16/chesscom-200-million-members/
31. The Guardian. (2020, November 24). Queen's Gambit sparks chess sales boom. https://www.theguardian.com/games/2020/nov/24/queens-gambit-sparks-chess-sales-boom
32. Variety. (2020, November 23). 'Queen's Gambit' drives chess resurgence. https://variety.com/2020/tv/news/queens-gambit-chess-sales-1234842382/
33. WIRED. (2021, February 16). How PogChamps made chess cool again. https://www.wired.com/story/how-pogchamps-made-chess-cool-again/
34. Bayeck, R. Y. (2018). Board games and learning: Why care in the digital age? In Learning and education in the digital age. IntechOpen. doi: 10.5772/intechopen.80386
35. Camuñas-García, D., Cáceres-Reche, M. P., Cambil-Hernández, M. D. L. E., & Lorenzo-Martín, M. E. (2024). Digital game-based heritage education: Analysing the potential of heritage-based video games. Education Sciences, 14(4), 396. doi: 10.3390/educsci14040396
36. Kang, X., Ying, Y., Lin, X., He, K., Li, X., & Bai, X. (2024). Research on the application of gamified learning of traditional bamboo papermaking skills in the dissemination of intangible cultural heritage. In Proceedings of the 2024 5th International Conference on Mental Health, Education and Human Development (MHEHD 2024) (pp. 526–532). Atlantis Press. doi: 10.2991/978-2-38476-271-2_21
37. Lin, C. F., Chen, Y. R., & Shih, R. C. (2022). Effects of technology-enhanced board games in primary mathematics education on students' learning performance. Applied Sciences, 12(22), 11356. doi: 10.3390/app122211356
38. Mendes, J., & Correia, J. (2023). Playing at the school table: Systematic literature review of board, tabletop, and other analogue game-based learning approaches. Frontiers in Psychology, 14, 1160591. doi: 10.3389/fpsyg.2023.1160591
39. Phongsophol, K., Charoenkitkarn, N., & Raksapetch, B. (2024). The game of heritage: Enhancing virtual museum visits through gamification for tourists. TEM Journal, 13(4), 3359–3372. doi: 10.18421/TEM134-51
40. Sulaiman, R. S. A., & Samsudin, M. R. (2022). Designing children's traditional games through visual thinking in the socio-cultural concept. International Journal of Academic Research in Business and Social Sciences, 12(10), 2364–2373. doi: 10.6007/IJARBSS/v12-i10/15474

41. Varli, G., Varli, A., & Baki, Y. (2023). Experiencing cultural heritage through gamification. In Proceedings of the 41st eCAADe Conference (Vol. 1, pp. 211–218). https://papers.cumincad.org/data/works/att/ecaade2023_211.pdf
42. Ackermann, E. (2017). The learning wheel: A model of learning through making. MIT Media Lab. https://www.media.mit.edu/publications/the-learning-wheel-a-model-of-learning-through-making/
43. Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., & de Freitas, S. (2010). Developing serious games for cultural heritage: A state-of-the-art review. Virtual Reality, 14(4), 255–275. doi: 10.1007/s10055-010-0177-3
44. de Freitas, S., & Jarvis, S. (2007). Serious games—engaging training solutions: A research and development project for supporting training needs. British Journal of Educational Technology, 38(3), 523–525. doi: 10.1111/j.1467-8535.2007.00716.x
45. Gee, J. P. (2007). What video games have to teach us about learning and literacy. Palgrave Macmillan.
46. Ishii, H. (2008). Tangible bits: Beyond pixels. In Proceedings of the 2nd International Conference on Tangible and Embedded Interaction (pp. xv–xxv). Association for Computing Machinery. doi: 10.1145/1347390.1347392
47. Michael, D., & Chen, S. (2006). Serious games: Games that educate, train, and inform. Thomson Course Technology.
48. Mortara, M., Catalano, C. E., Bellotti, F., Fiucci, G., Houry-Panchetti, M., & Petridis, P. (2014). Learning cultural heritage by serious games. Journal of Cultural Heritage, 15(3), 318–325. doi: 10.1016/j.culher.2013.04.004
49. Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books.
50. Resnick, M. (2017). Lifelong Kindergarten: Cultivating creativity through projects, passion, peers, and play. MIT Press.
51. Squire, K. (2011). Video games and learning: Teaching and participatory culture in the digital age. Teachers College Press.
52. Ji, H., Hu, P., & El-Zanfaly, D. (2025). Reshaping craft learning: Insights from designing an AI-augmented MR system for wheel-throwing. Proceedings of the 2025 ACM Designing Interactive Systems Conference (DIS '25), 2549–2573. doi: 10.1145/3715336.3735844
53. Gao, Z., Li, J., Wang, H., & Feng, G. (2018). DigiClay: An interactive installation for virtual pottery using motion sensing technology. Proceedings of the 4th International Conference on Virtual Reality, 126–132. doi: 10.1145/3170427.3188492
54. Vinayak, & Ramani, K. (2015). Hand grasp and motion for intent expression in mid-air virtual pottery. Proceedings of the 41st Graphics Interface Conference, 49–57. doi: 10.5555/2788890.2788936
55. Li, W. (2024). PM4Pottery: A scriptable parametric modelling interface for conceptual pottery design using PM4VR. 2024 10th International Conference on Automation, Robotics and Applications (ICARA), 496–500. doi: 10.1109/ICARA61123.2024.10547660
56. Zhang, W., Huang, H., & Qiu, M. (2020). Design and implementation of virtual pottery space based on ceramic cloud service platform. 2020 7th IEEE CSCloud / 2020 6th IEEE EdgeCom, 145–150. doi: 10.1109/CSCloud-EdgeCom49738.2020.00032
57. Berserk Games. (2025). Tabletop Simulator [Computer software]. Steam Store. Accessed 19 September 2025. Available at: https://store.steampowered.com/app/286160/Tabletop_Simulator/
58. UNESCO. (2003). Convention for the Safeguarding of the Intangible Cultural Heritage. Adopted by the 32nd session of the General Conference of UNESCO, Paris, 17 October 2003. Available at: https://ich.unesco.org/en/convention
59. Valve Corporation. (2025). Steam [Online platform]. Accessed 19 September 2025. Available at: https://store.steampowered.com/

60. Stivaktakis, I. (2025). Crafts Board Game: An Analogue and Virtual Game for the Education and Safeguarding of Traditional Crafts [Software; open-source project, MIT License]. Accessed 19 September 2025. Available at: https://github.com/giannistiv/Crafts-Board-Game
61. Partarakis, N., Doulgeraki, V., Karuzaki, E., Galanakis, G., Zabulis, X., Meghini, C., Bartalesi, V., & Metilli, D. (2022). A web-based platform for traditional craft documentation. Multimodal Technologies and Interaction, 6(5), 37. doi: 10.3390/mti6050037
62. Pye, D. (1968). The nature and art of workmanship. Cambridge University Press.