care, judgment, dexterity

CRAEFT

Craft simulation and immersive craft training

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Executive summary

This is the first version of Deliverable 4.1. on craft simulation and immersive craft training. It presents the progress achieved from M1-M18.

Crafts, embodying rich cultural heritage and intricate techniques, face significant preservation challenges in today's rapidly evolving technological landscape. The deliverable at hand addresses these challenges, particularly focusing on training individuals in traditional crafts through digital means. Traditional crafts such as woodworking, pottery, textiles, and basket weaving, though culturally and historically significant, suffer from dwindling interest, economic limitations, and the absence of structured, written instructional formats. The preservation and transmission of these crafts are further complicated by the need for authentic materials, adaptation to cultural shifts, and competition from mass-produced alternatives.

The central hypothesis of this deliverable is that eLearning and immersive training can provide substantial benefits for craft education. By leveraging platforms like Moodle, learners can access craft training resources irrespective of their geographical location, facilitating a global exchange of skills and knowledge. eLearning platforms offer structured, scalable repositories of instructional materials, accommodating diverse learning paces and reducing cognitive overload through the principles of Cognitive Load Theory (CLT).

This deliverable explores the integration of CLT within eLearning frameworks to enhance the learning experience for craft apprentices. By employing multimedia elements, interactive simulations, and self-assessment tools, eLearning can keep learners engaged while cost-effectively allowing for experimentation and practice. The focus on managing cognitive load ensures that instructional materials are designed to optimize learners' cognitive processing, making the learning process more efficient and effective.

Moodle is highlighted as an ideal platform due to its open-source nature and widespread use. However, the guidelines provided are platform-agnostic, offering a scalable solution for creating ergonomic, cognitive theory-based educational content across various eLearning systems.

The rest of the deliverable is structured as follows:

Chapter 2 makes an introduction on the background and related work focussing on highlighting approaches to providing efficient eLearning content which is essential for training heritage crafts since the learning subject heavily depends on the interaction of the maker with the material, which cannot be replicated online. As such, the background focus is on identifying appropriate ways of transferring some aspects of this knowledge through online courses.

Chapter 3 aims to elucidate the principles of CLT and its various effects, highlighting their relevance in the context of craft eLearning and applying these principles as encompassed into instructional design, learning strategies, and assessment methods. To do so, this chapter provides practical guidance on the implementation of CLT effects via application guidelines that are provided for each of the theory’s

effects. These guidelines are practically implemented for the design of case study eLearning content for the use case of glassblowing.

Chapter 4 focuses on, the application of the guidelines is illustrated through Moodle-enhanced eLearning experiences for craft education. The main aspiration is that through this work, educators, eLearning practitioners, and cultural heritage advocates will be equipped with a solid framework to enrich the teaching and learning of crafts in the digital age.

Chapter 5 presents the Apprentice Studio an advanced, immersive training platform designed to facilitate the learning and mastering of traditional crafts. It is part of a comprehensive ecosystem that includes the Craft Studio, which authors and exports lessons that are then imported and executed within the Apprentice Studio.

Chapter 6 presents Craft Studio which is a sophisticated and integral component of the immersive training ecosystem, tailored for craft masters to create, manage, and evaluate training lessons for apprentices. It offers a comprehensive suite of tools and functionalities designed to facilitate the design and delivery of engaging, interactive, and effective training sessions.

Chapter 7 provided conclusions on what was presented in this first version of the deliverable.

The content of this deliverable has been the basis for the following publication: Partarakis, N.; Zabulis, X. Applying Cognitive Load Theory to eLearning of Crafts. Multimodal Technol. Interact. 2024, 8, 2. https://doi.org/10.3390/mti8010002

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Abbreviations

AR	Augmented Reality
3D	Three Dimensional
CH	Cultural Heritage
CERFAV	Centre for Research and Training in Glass Arts
CLT	Cognitive Load Theory
CMS	Content Management System
DIY	Do It Yourself
GA	Grant Agreement
G_WEE	Guideline Worked Example Effect
G_PCE	Guideline Problem Completion Effect
G_SAE	Guideline Split-Attention Effect
G_MDE	Guideline Modality Effect
G_RDE1	Guideline Redundancy Effect
G_ERE	Guideline Expertise Reversal Effect
G_GFE	Guideline Guidance Fading Effect
G_IME	Guideline Imagination Effect
G_SEE	Guideline Self-Explanation Effect
G_EIE	Guideline Element Interactivity Effect
G_HG	Guideline Horizontal Guidelines
H5P	HTML5 Package
VR	Virtual Reality

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1. Introduction

Crafts represent a valuable repository of cultural heritage, encapsulating the wisdom and craftsmanship passed down through generations. These crafts encompass a diverse array of artistic, functional, and cultural practices, ranging from woodworking and pottery to textiles and basket weaving [1]. With their intricate techniques, cultural significance, and historical context, crafts stand as a testament to human creativity, innovation, and cultural preservation. In a world marked by rapid technological transformations, the preservation of crafts is of significance for their safeguarding [2].

Training individuals in crafts poses various challenges. It is of paramount importance to understand these challenges when trying to produce digital learning solutions that aim to support such goals 3]. The main challenge lies in preserving the authenticity of these crafts [4] while adapting to contemporary teaching methods. Other challenges are related to the nature of craft concerning the modern globalized environment [5]. These crafts are typically transmitted orally from one generation to the next, lacking a structured, written format that facilitates systematic education [6]. The absence of written records poses a significant risk of knowledge loss [7]. The mastery of crafts is a labour-intensive and time-consuming endeavour, with a dwindling number of individuals showing interest in apprenticeships. This decreasing interest in crafts raises concerns about their preservation [8]. Furthermore, the economic viability of these crafts remains limited, as they generally offer low financial returns [9]. Challenges also include the procurement of appropriate materials, adaptation to cultural changes, and the effective transfer of skills from experienced artisans to younger generations. Ensuring consistency in quality, addressing competition from mass-produced alternatives, and preserving the authenticity of crafts further complicate the training process. Moreover, access to markets, government support, and the revitalization of interest in crafts within communities are critical factors [10]. These multifaceted challenges underscore the need for comprehensive training approaches in crafts, whether technology-assisted or otherwise, to safeguard these invaluable cultural practices.

In this deliverable, a hypothesis is made that embracing eLearning and immersive training in crafts education can offer significant advantages. First and foremost, it introduces accessibility to craft education, breaking geographical boundaries. Learners from diverse locations can now access instructional materials and interact with instructors and peers, fostering a global exchange of craftsmanship. Moreover, eLearning platforms, such as Moodle, provide a centralized and scalable approach to education. They serve as a repository of knowledge, efficiently organized and catalogued for learners to explore. One of the most compelling benefits of eLearning is its ability to accommodate diverse learning paces [11]. Additionally, immersive training can support skills acquisition without the physical presence in a workshop or the physical presence of a tutor.

More specifically, concerning craft training, craft apprentices, often constrained by the rigidity of traditional settings, can now tailor their learning experiences to match their unique progress rates. eLearning ensures that learners are not overwhelmed by cognitive overload, offering ample time for the vital process of cognitive processing. This is particularly true when eLearning is designed to reduce intrinsic and extraneous cognitive loads [12]. Incorporating multimedia elements, interactive simulations, and self-assessment tools enhances the learning experience, keeping learners engaged and motivated [13]. At the same time, immersive interactive simulations can support free experimentation and practice without occupying a physical workshop and in a cost-effective way without the need for expensive material,

electric power for running the workshop, or any other material sources that are required to physically practice on a craft.

A critical issue in eLearning with a special application to craft is the management of cognitive load, a concept deeply rooted in cognitive psychology. Cognitive Load Theory (CLT) offers an intricate framework for understanding how the human cognitive system processes information and how the design of instructional materials [14] can shape the learning experience. eLearning platforms have been proven sufficient for the integration of principles from CLT, ensuring that instructional materials are thoughtfully designed to optimize the cognitive load of learners effectively [15–18].

This research work aims to bridge eLearning and immersive training on crafts with CLT, serving as a comprehensive guide for applying CLT effects in eLearning settings. eLearning platforms have revolutionized education, offering powerful tools and methods to enhance learning experiences [19,20]. It is argued that craft education can benefit from the principles of CLT. In the use cases described in this research work, the Moodle platform is employed [21] but any other eLearning platform can be suitable for applying the ergonomic knowledge developed by this research work. The rationale for selecting Moodle is the fact that it is an open-source, completely free eLearning platform that is currently used to implement more than 170k eLearning sites and more than 46M. courses. Of course, any other eLearning platform or CMS can be of use as a target system since the provided guidelines are platform-agnostic.

The innovation in providing guidelines to support training on traditional crafts lies in adopting a multifaceted approach that combines an established cognitive theory, such as CLT, with modern eLearning platforms. This fusion allows for a comprehensive understanding of cognitive processes while creating digital content for eLearning environments. These guidelines, rooted in cognitive phenomena, aim to optimize craft learning experiences. Both the guidelines and their application on a widely used eLearning platform are innovative dimensions in craft training. They offer a practical and scalable solution for crafting educational content in traditional crafts. This approach not only acknowledges the unique challenges of traditional craft education but also pioneers a new pathway for integrating cognitive theories into the digital landscape, enhancing the pedagogical strategies employed in training on traditional crafts.

2. Background and related work

Craft education and training are challenging since they introduce learners to a multifaceted world, where they must acquire skills, knowledge, and appreciation for cultural heritage. Balancing these learning objectives is a cognitive challenge. At the same time, the “low status” and “lack of prestige” of vocational options demotivate young people from following craft training [22]. In this work, we try to address the cognitive challenge building on CLT, as conceptualized by John Sweller [14]. This theory offers guidance on how to structure instructional materials and virtual environments to optimize the learning process. Understanding and addressing the different facets of cognitive load when designing eLearning courses [15] can foster effective learning [16], reduce cognitive overload, and facilitate deep engagement with crafts.

The significance of integrating CLT within the realm of craft eLearning becomes evident as we consider the vast potential to enhance the educational experience. Tailoring eLearning materials and Moodle-based activities to accommodate the complexities of crafts and the distinct needs of learners can empower individuals to engage more deeply with these crafts. The successful application of CLT through Moodle stands as a bridge between tradition and innovation, safeguarding the preservation, appreciation, and continuation of crafts.

This section provides a comprehensive overview of the theoretical foundations and existing research in the domains of CLT, craft education, and eLearning platforms, with a particular focus on Moodle-based learning environments.

2.1. Cognitive Load Theory

CLT is a foundational framework in educational psychology that underpins our approach to designing effective eLearning experiences for crafts. CLT delves into the intricacies of how the human cognitive system processes information and how instructional materials’ design influences the learning experience. The framework identifies three distinct types of cognitive load: intrinsic, extraneous, and germane. Intrinsic cognitive load relates to the inherent complexity of the subject matter, extraneous cognitive load pertains to the load imposed by ineffective instructional design, and germane cognitive load concerns the cognitive effort that leads to meaningful learning.

The core effects associated with CLT have a close relevance in eLearning contexts and include the Split-Attention Effect, which underscores the significance of not overloading learners with disparate sources of information [23]. The Modality Effect highlights how presenting information through multiple sensory channels can enhance comprehension and retention [24]. The Redundancy Effect emphasizes the negative impact of presenting the same information redundantly in different modalities [25]. In contrast, the Expertise Reversal Effect reminds us that what is effective for novices may not work for experts [26]. We will also consider the Guidance Fading Effect, which suggests that as learners gain proficiency, guidance should be gradually reduced, and the Imagination Effect which underlines the power of mental imagery in learning [27]. The Self-Explanation Effect advocates for learners to articulate their understanding [28], and the Element Interactivity Effect [29] focuses on handling complex, interactive topics.

2.2. Craft Education via Online Social Platforms

Currently, there are several platforms dedicated to teaching crafts. For example, Craftsy is an online platform that offers video courses on a wide range of crafts, including knitting, quilting, sewing, and more [30]. Users can access pre-recorded classes taught by expert instructors. Udemy hosts a variety of online courses on crafts and DIY projects. Instructors from around the world create and offer these courses. While the quality and content can vary, it provides a diverse range of craft-related courses [31]. Skillshare is an eLearning platform that offers a wide range of courses, including those related to crafts and DIY. It is known for its creative and practical courses, with many focused-on crafts. The Great Courses offers a selection of video courses, and they have offerings related to crafts. These courses are often taught by experts in their respective fields [32]. While not a dedicated eLearning platform, YouTube has a vast library of craft tutorials. Many artisans and crafters share their knowledge and skills through video tutorials [33]. This offers a wealth of free resources for those interested in crafts. Some craft schools and workshops have adopted eLearning and hybrid learning models. They offer both in-person and online classes, making craft education more accessible to a wider audience.

2.3. Moodle as an eLearning Platform

Moodle is a versatile open-source eLearning platform renowned for its rich feature set and widespread adoption in education and training [34]. Educators can seamlessly create and manage online courses, incorporating multimedia content, interactive assignments, and automated assessments. The user-friendly interface promotes easy navigation for instructors and learners alike. Moodle's flexible design allows for extensive customization with themes and plugins, ensuring it can be tailored to diverse educational needs. Its comprehensive gradebook and analytics tools facilitate learner progress tracking and performance evaluation. Moodle's robust security measures prioritize data protection, and its mobile accessibility caters to various devices, making it an excellent choice for modern eLearning. With a supportive global community and seamless integration capabilities, Moodle remains a top choice for educational institutions, corporations, and organizations worldwide [35].

2.4. Extending Learning Paradigms in Craft Education

In craft education, focusing on digital transformation while preserving the essence of craftsmanship and cultural heritage is important. The landscape of learning paradigms in craft education currently includes or has the potential to include in the future several novel learning approaches such as:

Blended Learning Models: craft education often thrives on hands-on learning, apprenticeships, and the transfer of practical skills from one generation to the next [36]. The fusion of practices with digital tools and platforms, such as Moodle, can create blended learning models that combine the tactile experience of crafting with digital resources.

Microlearning and Skill-Based Learning: As the educational landscape evolves, microlearning has gained prominence [37] in the context of crafts. Delivering skill-based modules in small, easily digestible segments through eLearning platforms is such a paradigm.

Gamification and Interactive Learning: Interactive and game-based learning approaches [38] can engage learners and make the process of acquiring craft skills more enjoyable. Gamified elements can encourage learners to explore the art of crafting while mastering skills in an immersive, enjoyable manner [39].

Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality(MR): New immersive technologies have a good track record in education and training and have been used in the field of Craft training [40–47]. eLearning as a digital form of education has the potential to support or be combined with immersive learning experiences with the benefit of being able to emphasize their ability to simulate real craftwork environments.

Personalized Learning and Adaptive Platforms: Personalized learning experiences tailored to individual learners can be facilitated in contemporary education.

Lifelong Learning and Cultural Preservation: craft education often extends beyond formal schooling, making lifelong learning essential.

3. CLT for Craft Practice Education and Training

Proposing craft-related guidelines for the application of the CLT effects in the eLearning context is the objective of this section. Although the proposed guidelines can be applied to other eLearning contexts too, in the context of this work we are focusing strictly on how to enhance eLearning in traditional craft contexts.

To simplify the understanding and application of these guidelines, we have kept the same structure as in CLT and thus we are providing guidelines per effect. The consolidation of these guidelines resulted in the definition of a small set of guidelines that can be applied horizontally and these are presented in a separate section. The validation of the usage of these guidelines is provided in Section 7 through a use case of implementing eLearning education and training material for a representative craft instance.

3.1 Effects of CLT Considered in this Work

This section provides a short introduction to the effects of CLT, before moving forward to the definition of practical guidelines for their implementation in the eLearning context.

The Worked Example Effect refers to providing learners with worked examples or step-by-step solutions to problems before they attempt to solve similar problems. This effect aims to enhance learning and problem-solving skills by allowing learners to see how a task or problem is solved before they try it themselves and is applied by (a) the provision of exemplar solutions or models of how to solve a particular type of problem, (b) Scaffolding Learning by providing learners with guidance and support, and (c) Gradual Release of Responsibility by limiting over time the level of guidance provided.

The Problem-Completion Effect aims to ensure that learners pay sufficient attention to the worked examples to provide learners with completion problems [45]. A completion problem is a partially worked example where the learner has to complete some key solution steps. Sweller [48] asserted that completion problems are effective because they incorporate a problem-solving component, prompting learners to engage with the problem at a sufficient depth to grasp crucial information. This approach avoids overloading working memory by steering clear of complete problem-solving. In completing the problem, learners are required to focus on and process the pre-solved portion before responding to the unfinished steps. Essentially, completion problems represent a hybrid approach, combining aspects of both a worked example and a problem to be solved [49].

The Split-Attention Effect occurs when learners need to divide their focus between at least two sources of information that are intentionally separated either spatially or temporally [50]. Spatial split attention occurs when a learner is required to simultaneously focus on two or more spatially separated sources of information. This occurs when information that is essential for understanding a concept is presented in different locations or on different parts of a display. In such cases, the cognitive load increases as individuals need to split their attention between multiple sources, which can hinder comprehension and learning. Temporal split attention refers to the division of a learner's attention over time due to the presentation of information at separate points in time. It occurs when critical information is presented in a manner that requires individuals to remember and integrate information from an earlier point in time when processing subsequent information.

The Modality Effect refers to the idea that people learn more efficiently when information is presented in multiple modalities (e.g., text and spoken words). The rationale behind the Modality Effect is that by engaging both the visual and auditory processing systems, learners have more opportunities to encode and consolidate the information, resulting in better learning outcomes [51]. This effect is related to the broader field of multimedia learning theory, which explores how the presentation of information in multiple modalities can impact learning and memory.

The Redundancy Effect refers to the principle that presenting the same information through multiple modalities (typically, visual and auditory) can lead to cognitive overload and reduced learning effectiveness. In other words, when learners are presented with redundant information, where the same content is provided in both written text and spoken narration, it can have a negative impact on their ability to comprehend and remember the material [25]. The Redundancy Effect is the opposite of the Modality Effect, which suggests that presenting information in multiple modalities enhances learning. The key distinction is that while the Modality Effect advocates for using different modalities to convey complementary information (e.g., visuals and spoken explanations), the Redundancy Effect warns against presenting the same information in redundant ways (e.g., showing on-screen text and simultaneously reading it aloud). Both Modality and Redundancy Effects are a subject of constant research as new media and learning technologies arise [52–55].

The Expertise-Reversal Effect describes how the impact of instructional methods can change based on the level of expertise or prior knowledge of the learners. In essence, it suggests that what is an effective teaching strategy for novices may not be as effective for experts and vice versa [56].

The Guidance-Fading Effect involves gradually reducing the level of guidance provided to learners as they gain proficiency and expertise in solving problems or completing tasks. The key elements of the Guidance-Fading Effect include (a) guidance at the beginning of the learning process with detailed step-by-step guidance, such as fully worked examples or explicit instructions [57]; and (b) a gradual reduction in guidance so as for learners to become more familiar with the problem-solving or task-completion process and demonstrate proficiency, the level of guidance is progressively reduced. Independence is the ultimate goal to empower learners to solve problems or complete tasks independently, relying on their own understanding and problem-solving skills.

The Imagination Effect is a cognitive phenomenon in which individuals tend to remember information or concepts more effectively when they actively engage their imagination to visualize or mentally simulate the content they are trying to learn [58]. By mentally creating vivid images or scenarios related to the material, learners can enhance their understanding and retention of the information. This effect suggests that imagination and visualization can be powerful tools for encoding and recalling knowledge.

The Self-Explanation Effect is a learning and cognitive phenomenon that pertains to the practice of self-explanation. It involves learners explaining concepts, problems, or solutions to themselves in their own words as they engage with educational materials. When individuals actively articulate and clarify their understanding, they tend to learn and retain information more effectively [28]. Self-explanation helps learners identify gaps in their comprehension and reinforce their grasp of the subject matter, promoting deeper understanding.

The Element Interactivity Effect refers to the idea that the difficulty of learning and understanding a particular topic or subject is influenced by the degree of interactivity or complexity among the elements or components of that topic. This effect suggests that learning is more challenging when the subject

matter is highly interactive or when multiple elements must be understood relative to one another [29]. The complexity and interdependence of these elements can make it more difficult for learners to grasp the material, particularly for novices or learners with limited prior knowledge.

3.2. Guidelines per CLT effect

The proposed guidelines are the results of working with craft practitioners, craft communities, and craft training organizations in the context of the Horizon2020 project Mingei and the Horizon Europe project Craeft. In Mingei, a protocol for craft representation and presentation has been developed as the outcome of the interdisciplinary effort between heritage scientists, ethnographers, anthropologists, craft practitioners, digitization experts, and experts on modern ICT technology [59]. This protocol sets the foundations for understanding traditional crafts and presenting them for information, education, and training.

Rooted from this protocol, in Craeft, the objective is to propose advanced ethnographic strategies for craft understanding and the application of modern technologies in craft training. Part of the scientific process was the analysis of current craft training curricula in collaboration with craft training institutes in Europe such as the European Center for Research and Training in Glass Arts (CERFAV). CLT was considered since it is well-suited for digital training methods. In collaboration with craft training organizations, we formulated the wireframes of exemplary courses that could bring part of the training process in an eLearning context. These wireframes were then studied in conjunction with the available digital material such as (a) ethnographic recordings from a glass workshop, photographic documentation, (c) 3D models of tools, machines, and the workshop itself, (d) rendered virtual representations of the workshop, (e) visual abstractions of fundamental glassblowing actions in the form of rendered 3D animations, (f) visual abstractions in the form of cartoonized images, and (g) educational material from textbooks regarding the glassblowing craft.

The next step was to study the facilities offered by modern eLearning systems in terms of authoring interactive and multimodal training material. This was important in order to identify the forms of training experiences that can be supported by the current state of the art in conjunction with the availability of the aforementioned digital material. During this study, the guidelines discussed in this section were authored to optimally bring together digital material and training experiences.

3.2.1 Worked Example Effect

The Worked Example Effect can be applied to the eLearning context through the application of the following guidelines:

- G_WEE1. Provide craft-specific worked examples in the form of step-by-step demonstrations of key techniques and processes;
- G_WEE2. Use high-quality visuals and depict the fine details of the craft and use close-up shots and visualization to help learners see intricate work;
- G_WEE3. Include narration and explanation alongside the visual demonstrations to explain the purpose and significance of each step, the tools and materials used, and any historical or cultural context;

- G_WEE4. Demonstrate variations in techniques and styles that are relevant to the specific craft since different regions and cultures may have their unique approaches;
- G_WEE5. Incorporate hands-on interactive activities that allow learners to practice the techniques they have observed (through imitation) such as virtual workshops and simulations;
- G_WEE6. Provide progressive complexity on the worked examples and interactive activities starting with basic techniques and gradually introducing more complex skills;
- G_WEE7. Offer information on the tools and materials used in the craft to explain their purposes, how to select them, and where to obtain them;
- G_WEE8. Emphasize safety guidelines and best practices, particularly for crafts that involve potentially hazardous tools or materials;
- G_WEE9. Organize field trips (including virtual trips) and invite guest artists and crafts persons to share their experiences and expertise with learners.

3.2.2 Problem Completion Effect

The following guidelines are proposed for applying the Problem-Completion Effect:

- G_PCE1. Introduce learners to craft projects that are partially completed, especially in the case of complex or multi-step tasks;
- G_PCE2. Ensure that the partially completed craft project represents the initial or starting state of the craft to help learners understand the project's context and how to proceed;
- G_PCE3. Accompany the partially completed project with explanations of the techniques and steps taken to reach that point to help learners understand the craft's methodology and thought process;
- G_PCE4. After presenting the partially completed project, encourage learners to actively engage with it. This can include asking them to complete the remaining steps, add intricate details, or identify areas for improvement;
- G_PCE5. Over time, gradually reduce the level of completion provided in the partially finished craft projects to align with learners' increasing proficiency and confidence in completing similar projects independently;
- G_PCE6. Offer constructive feedback on learners' attempts to complete the partially finished craft projects to reinforce correct techniques and address misconceptions;
- G_PCE7. Present a range of craft projects with varying levels of complexity, gradually increasing in difficulty;
- G_PCE8. Encourage meta-craftsmanship by motivating learners to think about their craft process and reflect on the techniques and strategies they use, thus helping them develop problem-solving skills specific to crafts;
- G_PCE9. Scaffold craft learning by providing more guidance for novice learners in the early stages of craft training and gradually reducing the level of support;
- G_PCE10. Consider craft context by applying the Problem Completion Effect in a way that aligns with the specific craft context and objectives. Different crafts may require tailored approaches based on the craft's nature and cultural significance;
- G_PCE11. Encourage collaborative craftsmanship. Learners can work in pairs or groups to complete partially finished craft projects, fostering discussion, sharing traditional techniques, and peer learning within the craft community.

3.2.3. The Split-Attention Effect

When considering spatial split attention, the following guidelines come into use:

- G_SAE1. Organize eLearning content effectively to reduce the existence of spatially separated sources;
- G_SAE2. Use visuals such as images or videos that are closely aligned with the accompanying text or explanations to help learners integrate information from a single source more easily;
- G_SAE3. Minimize scrolling that may disrupt the flow of information and lead to spatial split attention. Ensure that content fits within a single screen or provides clear navigational cues;
- G_SAE4. Provide sequential learning by presenting information in a logical sequence and avoiding introducing concepts that depend on earlier content before providing the necessary foundation;
- G_SAE5. Maintain a consistent pace throughout a lesson and provide sufficient time for learners to absorb the content before moving on;
- G_SAE6. Segment instructions by dividing complex instructions into smaller, manageable steps or modules allowing learners to focus on one step at a time and build their skills progressively;
- G_SAE7. Provide redundancy by using multiple formats. Combine text explanations with visuals or demonstrations, allowing learners to access the same information from different sources;
- G_SAE8. Ensure spatial contiguity by placing related information, such as written instructions and visual examples, nearby;
- G_SAE9. Ensure temporal contiguity by presenting sequentially information in a logical order, allowing learners to integrate it as they encounter it. Avoid jumping between past and present information;
- G_SAE10. Segment complex craft projects or techniques into smaller, manageable sections or modules to assist in the step-by-step understanding of crafts;
- G_SAE11. Facilitate signaling by using clear cues or markers to highlight relationships between different pieces of information such as arrows, connectors, or highlighting to indicate connections between text instructions and accompanying visuals;
- G_SAE12. Provide a summary or an overview before or after presenting information on a specific craft technique to help learners understand the big picture and how different elements are related;
- G_SAE13. Incorporate interactive elements into the eLearning materials and offer activities that allow learners to actively practice craft techniques, fostering deeper understanding.

3.2.4. The Modality Effect

For the Modality Effect, the following guidelines come into play:

- G_MDE1. Accompany text with narration to enhance comprehension and retention;
- G_MDE2. Use relevant visuals such as images, diagrams, and animations, alongside text and narration, to illustrate craft techniques, materials, and finished products, making the content more engaging and memorable;
- G_MDE3. Maintain consistency and ensure that content is presented similarly across different modalities (text, narration, visuals) to prevent confusion and reinforce learning;

- G_MDE4. Organize information into smaller, manageable sections or modules to allow learners to focus on mastering one aspect of the craft at a time, making it easier to process information in different modalities;
- G_MDE5. Incorporate interactive elements that encourage active engagement with the craft material. Create interactive exercises, simulations, or crafting activities that enable learners to apply what they have learned;
- G_MDE6. Give learners control over the pace of their craft learning and enable them to review and revisit content presented in different modalities as needed;
- G_MDE7. Minimize unnecessary distractions that can interfere with the processing of craft-related information presented in different modalities;
- G_MDE8. Keep eLearning content engaging by using storytelling, real-life examples, and relevant craft scenarios. Create content that captivates learner's interest, motivating them to engage with multiple modalities;
- G_MDE9. Test on various devices to ensure that the eLearning course is compatible with various devices and screen sizes to accommodate different learning preferences and environments, including those of craft enthusiasts who may access the course on different devices.

3.2.5. The Redundancy Effect

For the appropriate use of redundancy, the following guidelines can be followed:

- G_RDE1. Use redundancy sparingly and avoid presenting the same information in both text and narration unless it is essential for clarity or accessibility reasons. In the craft learning context, redundancy should be used judiciously, such as when explaining complex techniques;
- G_RDE2. Prioritize complementary information and leverage different modalities to present complementary content. For example, use visuals (images or videos) to visually demonstrate craft techniques while the narration provides explanations;
- G_RDE3. Consider the diverse needs and preferences of your craft learners. Some may benefit from redundancy, while others may find it distracting. Consider offering options for learners to choose their preferred modality, such as providing text and audio options;
- G_RDE4. Emphasize key craft points by highlighting key craft techniques, important terminology, or critical information. Emphasize the most vital content rather than reiterating every detail;
- G_RDE5. Allow craft learners to control the pace of content delivery. They should have the option to skip or replay redundant information based on their understanding and needs, promoting a personalized learning experience;
- G_RDE6. Engage craft learners through interactive elements such as quizzes, discussions, and problem-solving exercises. Interactivity can reinforce learning without relying solely on redundancy, making the learning experience more engaging.

3.2.6. The Expertise Reversal Effect

To ensure that all learners get content that is sufficient for their level of learning and expertise, the following guidelines are suitable:

- G_ERE1. Begin by assessing the learners' prior knowledge and expertise in crafts. Use pre-assessments, quizzes, or self-assessments to understand their current skill level and familiarity with craft techniques;
- G_ERE2. For novice craft learners with little or no prior knowledge, provide explicit and structured instruction. Use clear explanations, step-by-step guidance, and scaffolded learning activities to build a solid foundation in craft techniques. Emphasize foundational concepts, tools, and terminology commonly used in the craft;
- G_ERE3. For learners with moderate expertise in crafts, offer a balanced approach that combines guidance with opportunities for independent thinking and problem-solving. Provide guided problem-solving activities that encourage critical thinking and the application of craft knowledge to practical scenarios. Use real-world craft projects, case studies, and more advanced techniques to deepen their understanding and skills;
- G_ERE4. Highly knowledgeable craft practitioners should engage in open-ended, exploratory, and problem-based learning approaches. Encourage independent exploration, research, and self-directed learning, allowing experts to apply their advanced knowledge to real-world craft challenges and creative projects;
- G_ERE5. Utilize adaptive learning technologies or techniques that can adjust the level of instruction based on learners' responses and demonstrated expertise. This ensures that each craft learner receives content and activities appropriate to their skill level;
- G_ERE6. Provide options to mixed groups of craft learners with varying levels of expertise, consider offering multiple pathways or content modules that cater to different expertise levels within the same course. This allows craft learners to self-select the most suitable learning path.

3.2.7. The Guidance Fading Effect

To ensure that the level of guidance is always optimal while moving forward on a learning path, the following guidelines can be used:

- G_GFE1. Provide explicit and highly guided instruction for novice craft learners such as complete worked examples, detailed step-by-step solutions, or comprehensive instructions for craft projects. Clearly explain the concepts, techniques, and tools involved in crafts to build a strong foundation;
- G_GFE2. Continuously assess and monitor the progress of craft learners as they engage with the materials and complete projects and look for signs of increased proficiency and understanding. Use formative assessments, quizzes, or skill checks to gauge when learners are ready for reduced guidance;
- G_GFE3. Gradually reduce the level of guidance provided as craft learners demonstrate growing competence and familiarity with craft techniques. Begin by omitting some steps, providing fewer hints, or requiring more independent problem-solving;
- G_GFE4. Scaffold the craft learning experience, maintaining a balance between support and independence and adjusting the level of guidance according to the evolving needs of craft learners. Consider individualized learning paths based on each craft learner's skill development;
- G_GFE5. Use prompts and hints instead of providing complete solutions to nudge craft learners in the right direction when they encounter difficulties. These prompts should encourage them to think critically and apply their craft knowledge effectively;

- G_GFE6. Challenge critical thinking for more proficient learners by introducing open-ended or complex craft projects that require critical thinking, analysis, and the synthesis of techniques. Encourage them to explore alternative craft techniques and creative problem-solving strategies;
- G_GFE7. Encourage reflection and metacognition by prompting craft learners to reflect on their craft projects and the techniques they have applied. Encourage metacognition to foster a deeper understanding of their craft learning process. Ask them to journal their progress and reflect on what they have learned;
- G_GFE8. Be responsive to individual craft learner needs and offer support when needed. If some learners are struggling with particular techniques or projects, be ready to provide additional guidance or support to prevent frustration and ensure successful learning.

3.2.8. The Imagination Effect

To ensure that imagination supports learning, the following guidelines are essential:

- G_IME1. Visualize complex concepts by encouraging learners to visualize intricate craft techniques or artistic processes by providing detailed, descriptive language in the eLearning content. Use analogies or metaphors to simplify complex concepts and stimulate learners' imagination. Complement textual information with visuals, diagrams, and multimedia that help learners create mental images;
- G_IME2. Incorporate storytelling elements in your eLearning materials. Craft narratives and scenarios that depict the historical context or cultural significance of crafts. Engage learners' imagination by creating relatable situations that illustrate the key concepts and the creative journey of craftsmen;
- G_ IME3. Utilize interactive simulations or virtual environments to immerse learners in the world of crafts. This hands-on experience allows them to apply their knowledge in realistic scenarios, making abstract concepts more tangible. Provide opportunities for learners to experiment with craft techniques in a safe, virtual space;
- G_IME4. Develop creative assignments that require learners to produce craftwork, or understand other people's craftwork. These assignments can encourage imaginative thinking, problem-solving, and a deeper connection to the craft.

3.2.9. The Self-Explanation Effect

Developing critical thinking can be facilitated through the following guidelines

- G_SEE1. Incorporate self-questioning by encouraging learners to ask themselves questions as they study, such as "How is this craft technique applied?" or "Why is this design element important?". Self-questioning prompts active engagement and self-explanation, helping learners articulate their understanding;
- G_SEE2. Provide prompts within the eLearning content that guide learners in self-explaining craft concepts. For example, include questions like, "Can you explain the significance of this craft tradition in your own words?". These prompts serve as cues for learners to engage in self-explanation;
- G_SEE3. Reflect and summarize by encouraging learners to periodically pause and reflect on what they have learned in the context of crafts. They can create summaries, mind maps, or written

reflections to consolidate their understanding and explore how craft techniques connect with cultural heritage;

- G_SEE4. Incorporate opportunities for peer review and feedback on craft projects and explanations. When learners explain craft concepts to their peers, it reinforces their understanding and allows them to learn from one another;
- G_SEE5. Provide feedback on learners' self-explanations to reinforce correct explanations and offer guidance in areas where learners may need further clarification. Feedback promotes self-improvement and the development of nuanced understandings of crafts;
- G_SEE6. Integrate active learning activities that require learners to solve problems, complete craft exercises, and explain their thought processes as they work through the material. Active participation enhances self-explanation and hands-on craft learning;
- G_SEE7. Teach metacognitive skills that help learners monitor their understanding of crafts. Encourage them to reflect on their learning strategies and adjust their approaches as needed. Metacognition is closely tied to the self-explanation effect and can lead to more effective self-regulated learning.

3.2.10. The Element Interactivity Effect

For the Element Interactivity Effect, the following guidelines can be considered

- G_EIE1. Assess the learner's prior knowledge before designing your eLearning course on crafts. Gauge the appropriate level of complexity and interactivity based on the learners' expertise;
- G_EIE2. Break down complex topics related to crafts into smaller, manageable chunks of information. Present these chunks in a logical sequence or order, ensuring that learners grasp one concept before moving on to the next;
- G_EIE3. Use visual aids, diagrams, charts, and graphs to represent the relationships and interactions between elements of crafts. Visuals can make complex content more accessible and understandable, especially when explaining intricate crafting techniques or designs;
- G_EIE4. Provide explanations and examples that accompany the presentation of complex concepts in crafts. Use real-world examples or scenarios to illustrate how various elements interact within craft processes;
- G_EIE5. Incorporate interactive simulations or scenarios specific to crafts that allow learners to explore the interactivity of complex crafting systems. This hands-on experience can deepen their understanding of crafting techniques and artistic processes;
- G_EIE6. Offer structured guidance and scaffolding as learners work through complex craft topics. Provide hints, prompts, or step-by-step instructions to help them navigate intricate crafting methods and cultural contexts;
- G_EIE7. Encourage peer collaboration and discussion among learners studying crafts. Learners can benefit from sharing their understanding of crafting traditions, artistic interpretations, and techniques, providing different perspectives, and helping each other navigate the interactivity of crafts;
- G_EIE8. Offer opportunities for learners to pause and reflect. Encourage them to think critically about how the various elements of craft-making and cultural significance interact and how their understanding of crafts has evolved;
- G_EIE9. Implement frequent assessments and quizzes that focus on the interactivity of elements within the subject matter of crafts. Assess learners' ability to apply crafting techniques and understand the cultural context of crafts;

- G_EIE10. Provide feedback on assessments and encourage learners to review and revisit complex topics in crafts as needed. Feedback can help clarify misunderstandings about crafting processes and the historical background of crafts;
- G_EIE11. Teach metacognitive skills that help learners monitor and adjust their learning strategies, especially when dealing with highly interactive content related to crafts. Encourage learners to reflect on their learning experiences;
- G_EIE12. Encourage critical thinking and problem-solving skills, especially in the context of crafts. Complex and interactive subjects often require learners to think analytically, creatively interpret crafting techniques, and apply their knowledge in culturally meaningful ways.

3.2.11. Horizontal Guidelines

In general, the following horizontal guidelines can be applied when creating educational material in eLearning contexts:

- G_HG1. Regularly review and revise your eLearning craft content and adapt your eLearning materials on crafts based on learner feedback, performance data, and evolving needs. Keep the course content up-to-date and aligned with best practices in instructional design for craft education;
- G_HG2. Receive and offer feedback.
    - Gather feedback from craft learners to understand their preferences;
    - Provide timely and constructive feedback on learners' craft projects and techniques. Highlight what they did correctly and suggest improvements to enhance their craftsmanship;
    - Encourage learners to critique each other's work constructively, fostering improvement;
    - Encourage learners to take ownership of their craft learning journey.
- G_HG3. Encourage discussion, sharing, and peer learning. Create forums or discussion boards where learners can share their imaginative interpretations and associations related to crafts. Encourage learners to discuss their creative ideas, inspirations, and the emotional connections they form with the craft. Encourage peer collaboration and discussion within the craft learning community. More experienced craft learners can assist those with less expertise, creating a valuable learning experience for all participants;
- G_HG4. Be mindful of accessibility. Make the eLearning course content accessible to individuals with various learning needs, including those who may rely more on one modality than another. In certain cases, redundancy may be necessary to accommodate individuals with different learning needs, such as those with visual or auditory impairments. Ensure your craft eLearning course is accessible to all learners by providing alternative formats and options. Achieving such compatibility would require that web content is authored following the web content accessibility guidelines [60], which, of course, requires expertise, time, and resources. More analysis on adhering to these guidelines is out of the scope of this research work; however, we provide here some basic guidelines that would enhance the accessibility and usability of eLearning content and are easy to apply and integrate into your eLearning authoring workflow.
    - Make sure that standard web-based content complies with basic accessibility guidelines. Use headings, provide alternative texts for all visual elements, avoid using tables for layouts, use simple language, etc. Facilitate accessibility checkers embedded in html editors and check your content before publishing;

  - Make sure that your web-based content is easily located within a page. Use a screen reader to evaluate the accessibility of your navigation and whether users can easily locate eLearning content;
  - Provide audio-only alternatives for eLearning content by facilitating online text-to-speech facilities;
  - Provide descriptions of what is presented in video elements, and author subtitles for videos. Use video transcript tools to simplify authoring and provide access to the text of the transcript;
  - Provide users with control over the size of text and contrast settings to enhance visibility for users with reduced visual acuity;
  - Support text translations in multiple languages including translations of audio-visual contents, subtitles, alternative texts, and media element descriptions;
  - Ensure that eLearning site navigation is seamlessly and consistently presented across different languages;
  - Follow the guidelines presented in the previous sections to enhance the usability of web content. This will happen automatically since usability is strongly bound to the reduction of cognitive load.
- G_HG5. Evaluate learning outcomes. Assess the effectiveness of the instructional approach by measuring learning outcomes and learner satisfaction. Use feedback and data to make continuous improvements to the eLearning experience for crafts;
- G_HG6. Do not disregard the context.
  - Include case studies and craft history context to showcase the significance of crafts from a cultural or historical perspective;
  - Highlight the importance of preserving and documenting crafts. Discuss the role of contemporary technology in documenting and promoting these crafts;
  - Promote respect for tradition and cultural sensitivity and encourage learners to appreciate the heritage and significance of crafts.
- G_HG7. Celebrate independence. When craft learners reach the point of completing projects independently and mastering craft techniques, celebrate their achievements and emphasize the value of self-directed craft learning.

3.3. Good Practice Guide on Applying the Provided Ergonomic Knowledge

Guidelines, serving as directives for individuals to perform specific tasks effectively and efficiently, can provide a framework guiding designers and developers in making appropriate decisions [61]. For many years, guidelines have constituted an inexpensive and widely used tool. However, despite the indisputable value and importance of such knowledge, several studies investigating the use of guidelines and standards by designers and developers have concluded that they are frequently ignored. This is partly attributed to the challenging exploitability of such knowledge and partly due to the medium of its embodiment, which often gives rise to issues of ineffectiveness and a lack of user-friendliness [62].

To combat this issue, we have followed a dual approach in this research work. The first is to provide in this section a good practice guide that provides the basic principles for reusing these guidelines. The second is to provide use-case examples of their application in actual circumstances, which is the subject

of the next section. Use-case examples fall in the category of the Worked Example Effect discussed in the previous section.

3.3.1. Familiarization and Preparation

The first step in applying these guidelines would require the designer to achieve a basic understanding of the concepts of the effects of CLT through a one-page introduction, such as the one provided in Section 3. This introduction aims at providing basic orientation and being capable of following the guidelines provided per effect. The second step is to become familiar with the guidelines by simply studying them to understand how each effect should be considered during the design of the eLearning content.

Having achieved a familiarization with the concepts described by the guidelines, the next issue to be considered is the availability of instructional content or the capacity to develop different forms of instructional content. This is essential to define the basic tool set that will be used during authoring instructional content.

The next issue to be considered is the end users of the educational content and how these can be grouped based on their knowledge and expertise. This grouping will support the scaffolding of the training courses.

Next, how progress should be evaluated and the forms of exercises, assignments, and projects that are of interest for the specific eLearning content should be considered. A generic understanding of what is expected to be evaluated is sufficient for this phase of the design.

3.3.2. Design of Educational Content

Based on the aforementioned information, the designer of the eLearning course can start by defining an appropriate categorization. The category structure will provide the basic principles of scaffolding, will define the basic educational sections, and will guide the selection of modalities. At the same time, it will support the visualization of the type of assessment that will support the evaluation of the learning outcomes for each category. This will act as a good starting point for the creation of actual educational content.

Regarding the creation of such content, it is highly advised that the examples provided in Section 6.3 are studied. These examples do not cover exhaustively all the types of courses that can be authored by following these guidelines but are considered a good starting point. Studying these examples provides information on how to apply most of the effects presented in the previous section except for the Expertise-Reversal Effect and the Guidance-Fading Effect, which are most efficiently covered through scaffolding learning.

Regarding the evaluation of educational outcomes, studying the examples of Section 6.4 can provide useful ideas on different forms of assignments that can support different effects and achieve various educational goals.

3.3.3. Creativity in the Design of Educational Content

Although the application of the aforementioned guidelines is considered important in this research work, it cannot guarantee the success of the authored courses. As in any human activity, creativity plays a significant role in the authoring of craft educational content and can influence both the design and delivery of content. Crafting, by its nature, is a creative endeavour, and incorporating creativity into educational materials aligns with the hands-on and expressive aspects of traditional crafts. Creative authoring involves not only presenting factual information but also engaging learners' imaginations and fostering a deep connection to the craft. By infusing creativity into content creation, educators can employ diverse and innovative teaching methods that resonate with learners, making the educational experience more engaging and memorable. Creative instructional materials, such as visually compelling presentations, interactive simulations, and imaginative scenarios, capture learners' attention and facilitate a deeper understanding of craft concepts. Most of these aspects fall under the Modality Effect and cannot be simply dealt with by adhering to the provided guidelines. In this context, creativity can promote a dynamic and adaptive approach to content delivery, ensuring that educational materials remain vibrant and responsive to the evolving needs of learners.

3.3.4. Enhance Acceptability through a User-Centred Design Approach

Incorporating a user-cantered design approach, involving a small set of users from all targeted user groups in all stages of the design process, can greatly enhance the effectiveness of educational materials. Seeking feedback in the initial phases becomes a fundamental step in ensuring that the content is not only relevant but also aligns with the preferences and needs of the intended audience. Early involvement of users allows for the identification of potential challenges, misconceptions, or areas that require improvement, promoting a collaborative and learner-centric development process. This iterative feedback loop, integral to user-centred design, ensures that the final educational materials resonate well with users, enhancing engagement and overall effectiveness. By actively involving learners from the outset, educators and instructional designers can create content that is not only accurate and informative but also tailored to the specific requirements and expectations of the target audience.

4. Authoring eLearning courses – Craeft eLearning platform

This section presents the Craeft eLearning platform and demonstrates the usage of the aforementioned eLearning guidelines for the implementation of an eLearning course.

4.1. eLearning platform

4.2. Data sources

In the presented use case, the craft of glassblowing will be examined. In this use case, the material used for creating eLearning material is composed of:

- Ethnographic recordings from a glass workshop utilizing various such as mobile phones, cameras mounted on a tripod, and close-up views with handheld cameras;
- Photographic documentation of the workshop tools, machines, and layout including photographic documentation acquired during the creation process to capture key moments of the object's creation;
- 3D models of tools, machines, and the workshop itself;
- Rendered virtual representations of the workshop;
- Visual abstractions of fundamental glassblowing actions in the form of rendered 3D animations;
- Visual abstractions in the form of cartoonized images composed in the form of a comic book presenting the creation process;
- Educational material from textbooks regarding the glassblowing craft.

4.3. Using Guidelines to Create an Appropriate Category Structure for an eLearning Course

The application of the developed guidelines started by creating an appropriate category structure for structuring the eLearning courses. During this process, several guidelines were followed to provide a clear picture to the learners of what to expect in terms of educational units. The analysis of the category structure and some exemplary course structures per category are presented in Figure 1. Figure 1 also provides a mapping of the guidelines followed to visually demonstrate how an appropriate category structure can act as the point of departure for a successful eLearning course on glassblowing.

Throughout this section, inline codes within the screenshots and textual descriptions are used to provide information on the conformance with specific guidelines.

Figure 1. The proposed category structure.

As shown in Figure 1, for the glassblowing case, we provided a scaffolding strategy decomposed into three levels, each one corresponding to a different expertise level in terms of craft education. The first level is introductory to the craft instance and contains lessons on the social and historical context (contextual information) and also introduces the tools, materials, and glassblowing machines. The knowledge acquired is reinforced through critical thinking and problem-solving assignments. Each level is completed through student evaluation tests and an open round of discussion and feedback that allows the learners to provide feedback on the course and the course editors to provide feedback on the learners based on the performed assignments and evaluation tests. The completion of this level provided a generic yet clear understanding of the craft instance to be studied.

Levels 2 and 3 are consistent in terms of structure and are formulated under the perspective of sequential learning, allowing learners to keep their own pace but at the same time follow a well-defined learning path. This distinction remains throughout the levels, maintaining the same scaffolding strategy. For simplicity, we will analyse level 2 having in mind that the same information stands true for level 3.

Level 2 starts with an introduction to the techniques that will be studied, which in the case of level 2 are the fundamental techniques of glassblowing. Then, the techniques are presented in the form of visual abstraction, which in our case is a 3D representation of the techniques in the form of an animated scene that presents only the tools and their interaction with the material. This form of presentation provides craft-specific worked examples and at the same time minimizes the distractions from the environment. When these visualizations are studied, we continue by presenting the same techniques as executed in the

environment through audiovisual recording in a glassblowing workshop in which a glass master is performing the same techniques in the context of creating a glass artifact. These demonstrations enrich the previously studied visual abstractions and complement them through additional sources of information. The course continues with immersive training on basic techniques, which inevitably should happen outside the eLearning platform by using some form of immersion. In the context of the Craeft research project, 3D and VR 3D are to be integrated for immersive training complemented with haptic devices for transferring information from the digital world to the learner and vice versa.

After this first round of training, the course proceeds to combine basic techniques to formulate complete glassblowing examples. These are presented in the form of both visual abstractions and recordings in the same way presented above. Then a second round of immersive training is to take place where the learners are required to imitate what they learned previously in a virtual environment. The level continues with critical thinking and problem-solving exercises. These are both assignments that can be executed offline and assignments that can be integrated with workshop study lessons on-site. In both cases, these result in the submission of assignments by students. The level completes with the evaluation tests and the open two-way feedback round.

Already for the creation of the structure, we have applied or foreseen the application of more than 30 of the aforementioned guidelines. The following example will deep even more into the formulation of specific courses.

4.4. Exemplars Courses

4.4.1. Course in the form of a Multimodal Document

In this example, the basic structure of a simple course will be presented and authored in the form of a multimodal document (see Figure 2). The objective of the example is to emphasize key craft points by presenting the basic glassblowing techniques. The course is composed of several topics, each focusing on a single subject—in this case, a fundamental glassblowing technique—minimizing the need for the learners to split their attention in simultaneously presented techniques.

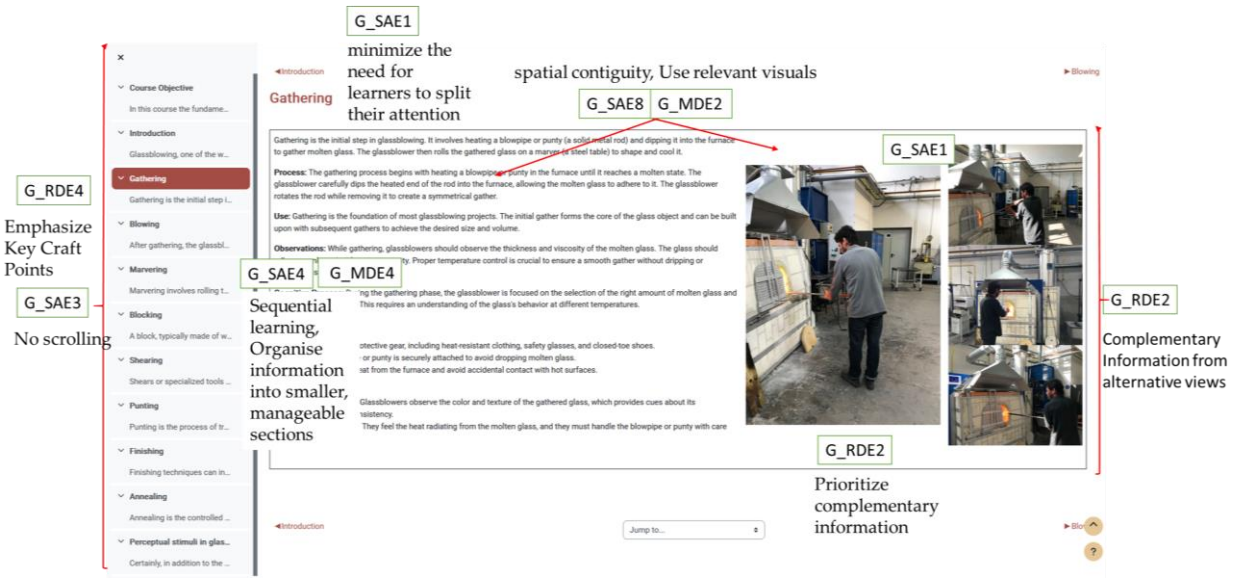

Figure 2. An example of a course authored in the form of a multimodal document.

Furthermore, the course is configured so that only one topic is presented on each page to organize information in small manageable sections and minimize the need for scrolling throughout the content. Following these guidelines, we have achieved the specific course to eliminate the need for scrolling. Navigation between topics is provided both on the left side of the course where the course structure is presented and inline where navigation to the previous and the next topic is provided both on top and after the content of the topic (see Figure 2).

Moving to the content of the course, as seen in Figure 2, the course is a collection of well-defined textual information organized based on their subject (Process, Use, Observations, cognitive processes, etc.). This offers a well-defined sequential flow of information and provides the ability for learners to study each subject separately. Furthermore, by integrating cognitive and perceptual information into the description of techniques, we create mental information that is stored in long-term memory. This information is retrieved in the working memory when actually performing the techniques in a physical setting.

To ensure spatial contiguity, visual information is presented right next to textual information to be studied in parallel. Regarding the use of visuals, complementary information is prioritized. The objective, in this case, is to provide alternative views of the same process from different viewpoints, thus ensuring that the same actions of the practitioner can be studied from complementary views, which is extremely important when studying gestural information.

4.4.2. Courses Embedding Audio-Visual Components

In this example, a course that presents visual abstractions of glassblowing processes is studied. A visual abstraction can be thought of as a 3D scene that contains only the tools and material and employs animation to mimic the events of a crafting process. By abstracting the process from the context, we can focus only on its essential parts.

An example of the blocking process in glassblowing is presented in Figure 3. To enhance the understanding of the content to be presented, the techniques and the steps followed are introduced shortly before the presentations of visual abstractions and shortly after to enhance self-questioning on the presented information. To further simplify the presentation of the technique, visual content is split into three steps, each presented individually, and the learner can control playback to study each step again and again. After completion, the student is prompted to confirm whether he has acquired the subject and wishes to move forward to the next subject or whether he wishes to be transferred to the next course in which the same technique is shown as practiced by actual practitioners. In this way, the learners can control the pace of their learning and information provision and define alternative ways of browsing information by navigating between courses. General considerations in eLearning craft courses are maintained in this lesson too by keeping the same course structure and a consistent pace through the presentation of the course content, eliminating whenever possible distractions and scrolling.

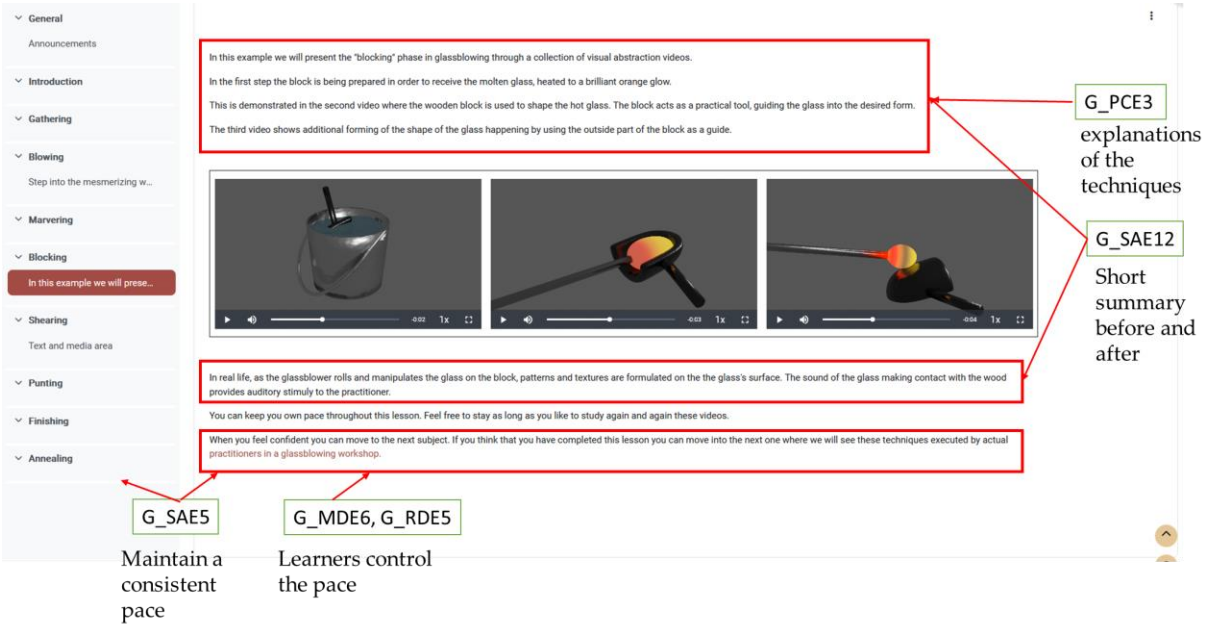

Figure 3. Example of a course embedding audio-visual components.

4.4.3. Course in the form of an Interactive Book

In this example, we are building on the h5p content compatibility of the eLearning platform to create two paradigms of interactive books.

The first paradigm is authored following principles of visual abstraction (see Figure 4). To do so, key frames from a glassblowing process are used as a summary of each action. To make content more interesting, the key frames are simplified using a cartoonification filter. The results are combined to author a comic book. Action sequences are complemented using inline textual descriptions following standard comic book principles. Using the capabilities offered by h5p content, we use the images illustrating each page of the comic to author an interactive book. To ensure that complex concepts are segmented into smaller and more manageable parts, each page of the interactive book has been authored in a way to presents only one step of the process. The placement of images follows the logical sequence of the steps. Inline visual annotations are used to highlight important parts of each action and the interaction between the

craftmaster, tools, materials, and workshop. The textual descriptions act as narrations of the visual information. Key locations are also enhanced by linking to the source audiovisual captures of the process to further study important steps.

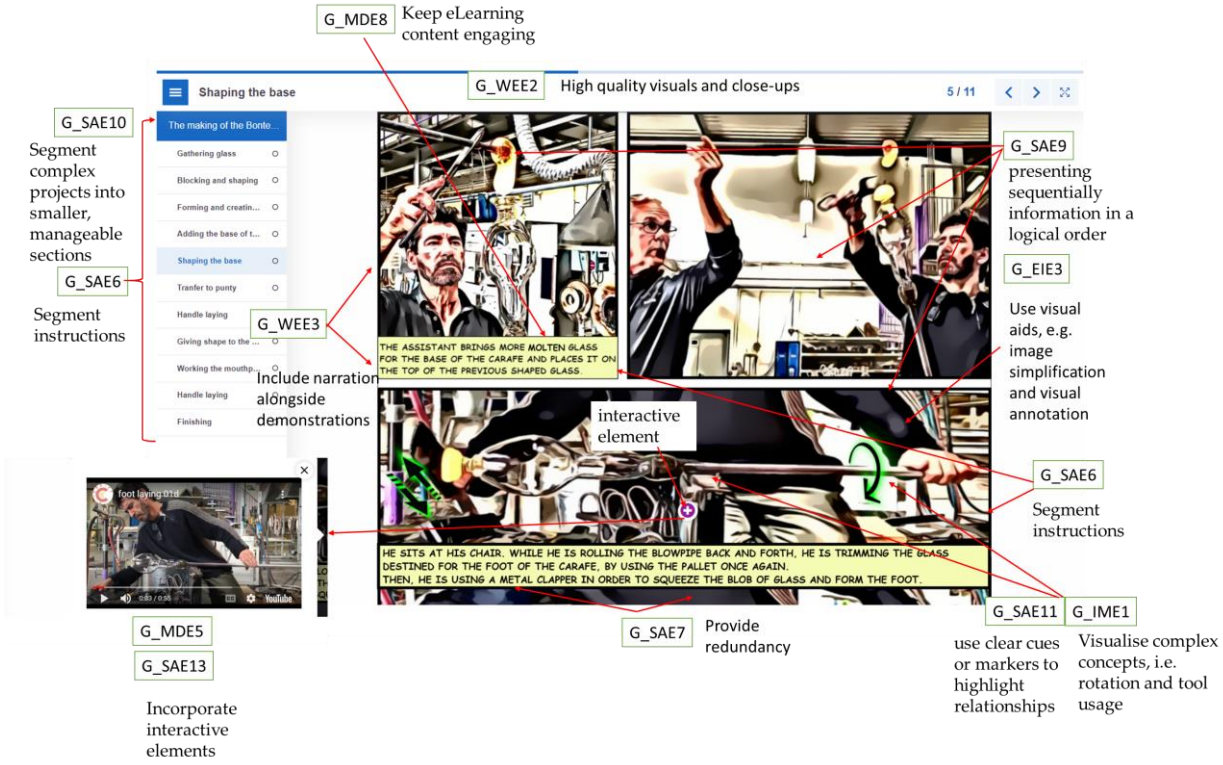

Figure 4. An example of a course in the form of an interactive comic book.

The second example builds on the same visual abstractions used for teaching individual glassblowing techniques now combined in a completely worked example that presents from the beginning to the end the implementation of a complex glass object, which in this use case, is a glass carafe. The same principles of organization in steps and of the provision of information sequentially are maintained in this example too. An indicative screenshot from this interactive book authored in the H5P format [63] is presented in Figure 5.

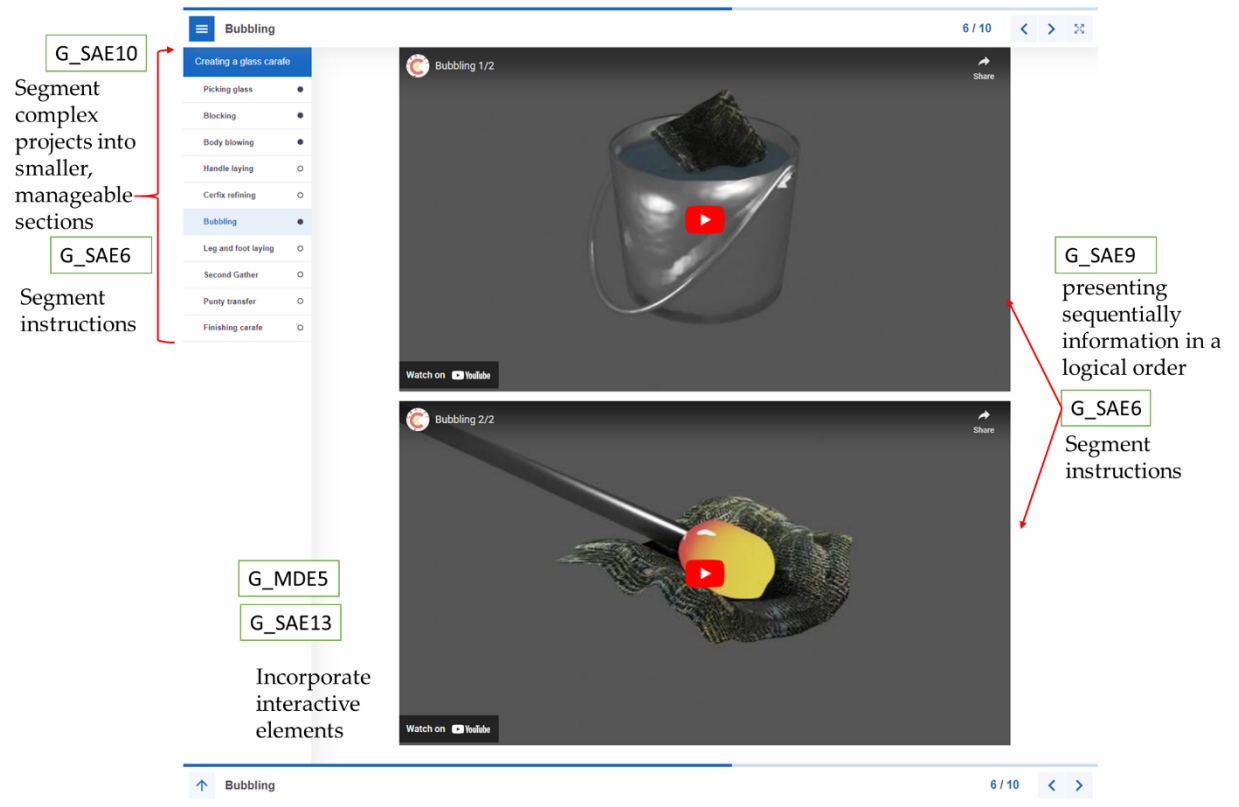

Figure 5. Example of a course that presents a complete worked example as a visual abstraction of steps.

4.5. Assignments and Student Evaluation

Student evaluation follows the method of assignments and tests enhanced through digital media to make them more engaging. In this section, examples of alternative evaluation means will be presented starting from plain old-fashioned multiple-choice quizzes and moving to more creative forms such as interactive video quizzes, problem-solving exercises, and creative assignments.

4.5.1. Multiple-Choice Quizzes and Interactive Video Quizzes

Multiple-choice quizzes are not the target of this research work and have been thoroughly studied by previous research works (e.g., [64–66]). In this work, we focused on providing through interactive quizzes various levels of feedback during the test to provide real-time information to the learners regarding their selections and thus transform the test into yet another form of learning. Several guidelines are easy to apply here too, such as maintaining a consistent pace in the presentation of questions, ensuring that no scrolling is required, using simple and consistent wording, providing incremental difficulty, etc.

Conversely, interactive video quizzes are considered a more innovative alternative to this research work since much of the craft training depends on observation, understanding, and mimicking. Such tests were created as part of this work using footage from actual practitioners and in our example, the creation of a glass carafe is studied. The footage used regards the demonstration of its creation process in the workshop by a glassmaster and his assistant. The video is interactive, employing pausing to several

keyframes to allow the student to be prompted with a question that is based on their understanding of the glassblowing process (see Figure 6). Thus, pausing by itself introduces a partially completed problem that allows the learner to exercise knowledge and critical thinking. Questions are formulated in the form of asking for a justification from the learner and questions provide several justifications of a phenomenon. In the case of success, the interactive video continues, while in the case of failure, feedback is provided to the learner to enhance their understanding of the phenomenon under study and the question itself.

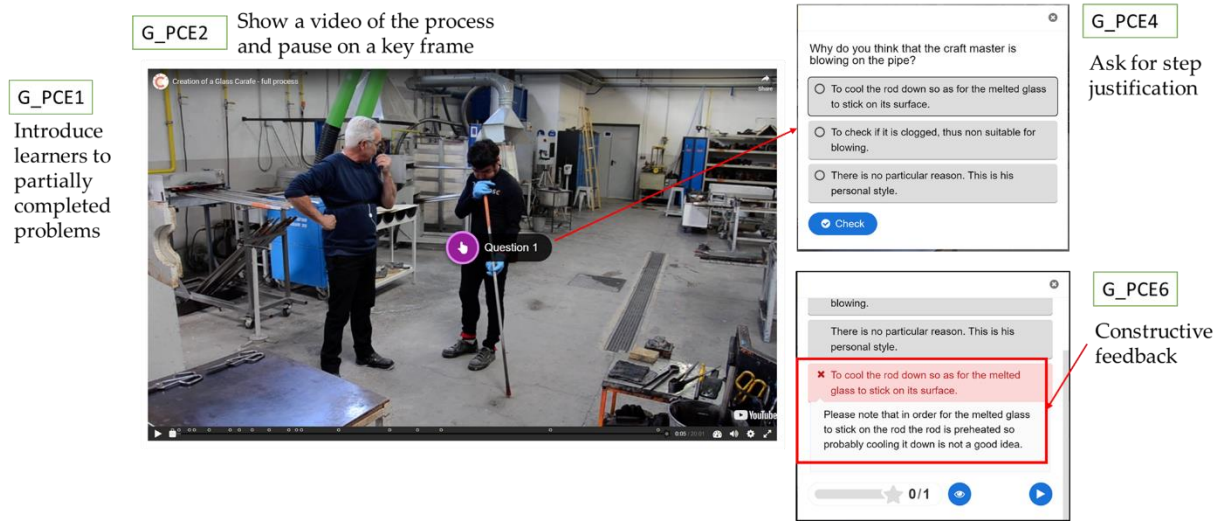

Figure 6. A video quiz and the relevant guidelines conformed to.

4.5.2. Problem Completion Assignments

In this example, we mainly study the Problem Completion Effect, in which the learners are introduced to a partially completed problem and prompted to practice their capabilities to fill in the missing pieces of information (see Figure 7). The presentation of the problem starts with a description of the context that the learners should focus on and a short description of the assignment. Then, explicit instructions on how to proceed with the assignment are provided alongside information on how their assignment will be assessed. The partially completed project is provided in the form of a partially filled answer template that the students should use as a starting point for their assignment. Furthermore, learners are strongly advised to work in groups to practice interpersonal collaboration and problem-solving skills. The structure of the aforementioned assignment is designed to support scaffolding learning by deactivating parts of the assignment based on the learner's level. Thus, for novice learners, the assignment has the exact structure and content as shown in Figure 7, while for moderate users only the instructions and an empty template are provided. For experts, only the objective of the assignment and an empty template are provided.

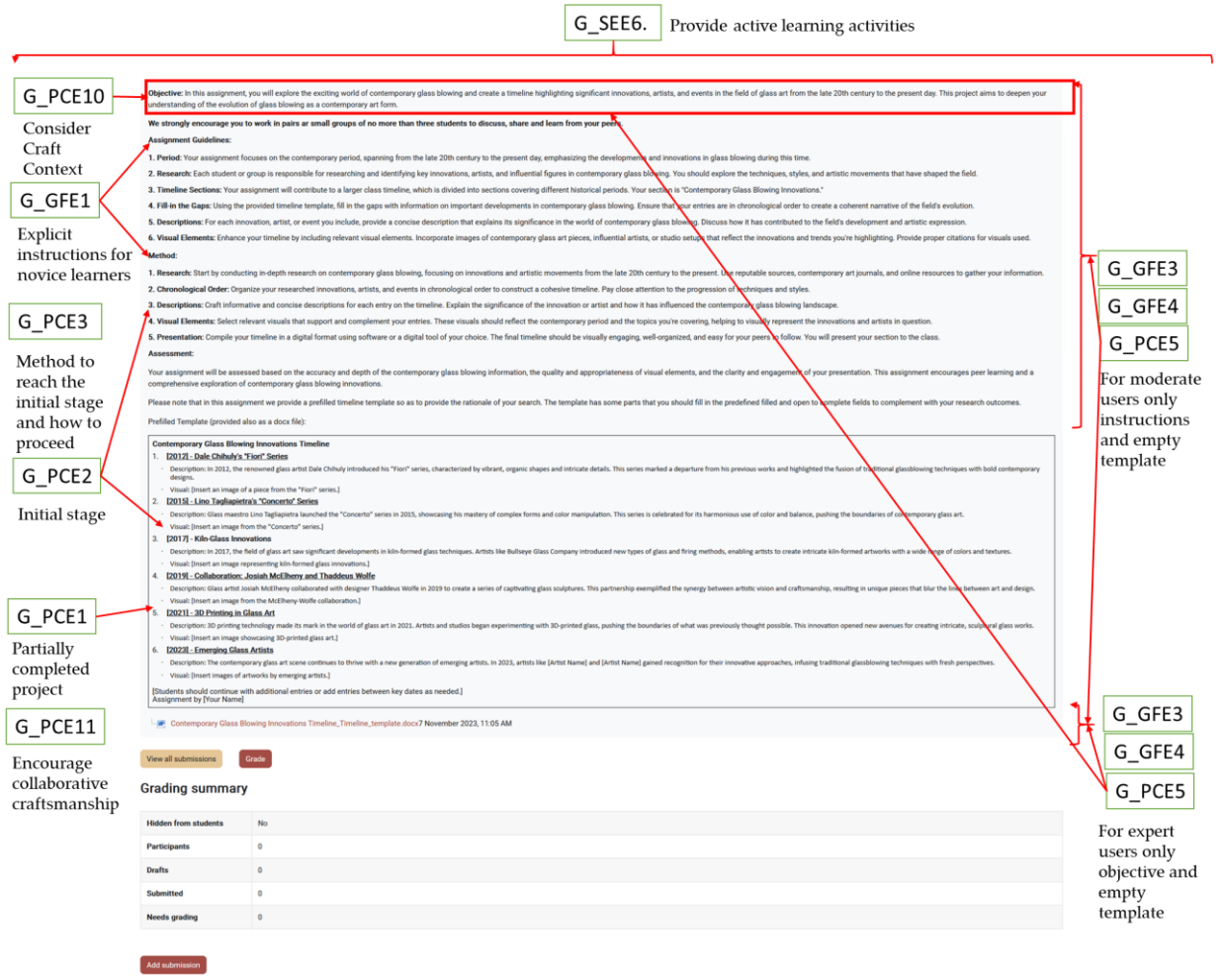

Figure 7. An example of an assignment focusing on the application of the Problem Completion Effect in crafts eLearning.

4.5.3. Creative Assignments

In this example, we study the creative assignments that develop critical thinking and analytical skills. The structure of the assignment, as shown in Figure 8, is divided into two sections. The first presents the objective of the assignment, while the second presents instructions in the form of a step-by-step walkthrough of how to execute the assignment. These step-by-step instructions allow the authors of the assignment to integrate strategic sub-tasks that, through their execution, can assist in the development of critical thinking and analytical skills rather than expecting this to magically happen. For example, the assignment provides specific instruction on what should be researched for each art artifact and the research itself is a way of transferring knowledge to the learner not only on this subject but in general on how to establish a new paradigm of collecting and evaluating knowledge from external sources. At the same time, it guides the learner with further instructions to focus on things that are considered essential, such as the artistic intent and the design elements, which can assist in cultivating creative thinking when composing works of art and in general creativity by identifying creative elements and their contribution to the composition. These instructions further provide incentives to the learners to search deeper into artistic creation and provide time for self-questioning since understanding and judging what you see is essential while gathering information on what to see. Combining inner beliefs with external knowledge

can become a generator of new ideas, designs, and creative concepts. Of course, the learners are strongly advised to discuss with their peers since through discussion, research, and consolidation, a more holistic understanding can be achieved.

The assessment of such an exercise is a reflective essay in which the learners are asked to summarize their analysis of the selected artefact highlighting key points focused by following the instructions and new creative directions generated throughout their research. The creative essay acts as a form of self-explanation, inviting the learners to explain to themselves while preparing the essay the path, focal points, and decisions made during their research.

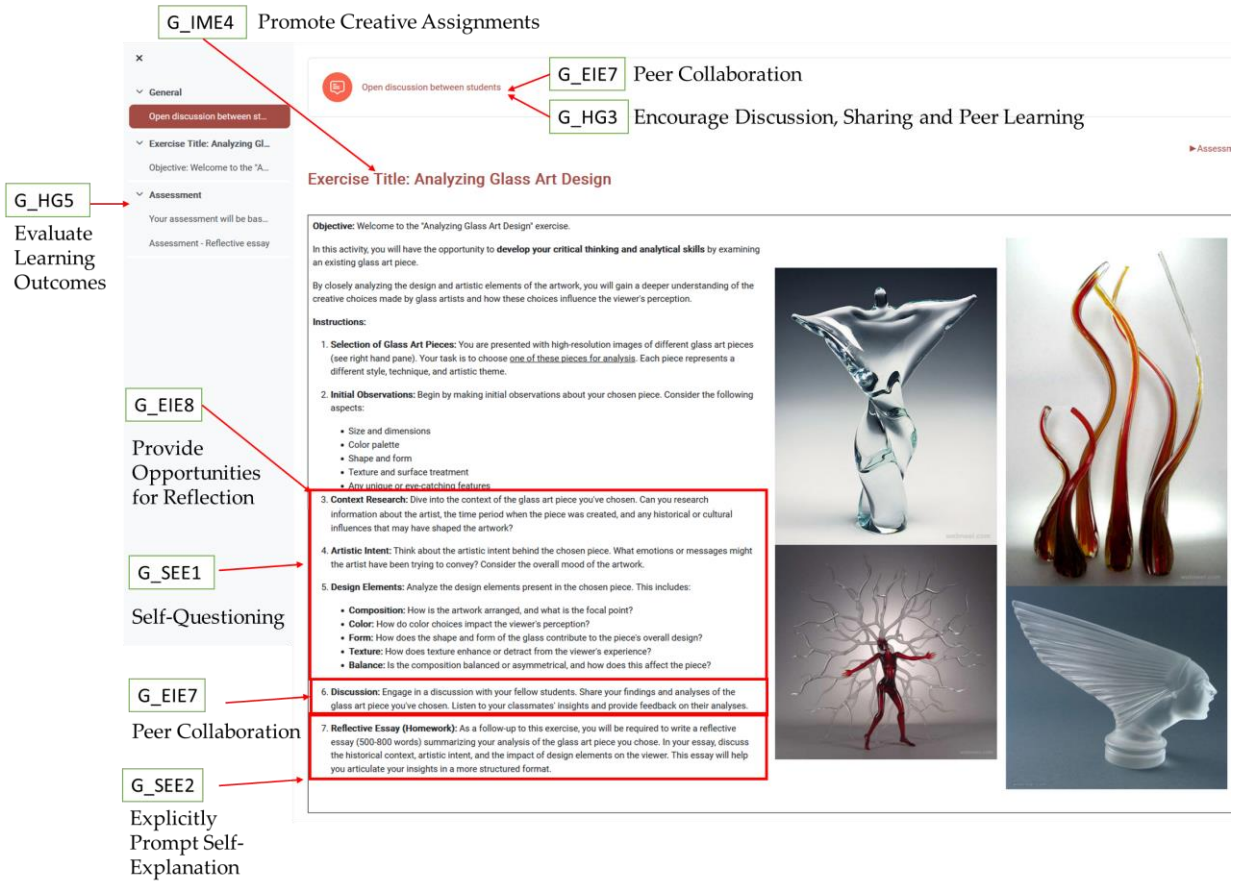

Figure 8. An example of a creative assignment.

5. Applying Guidelines for immersive craft training

This section provides the current version of the Apprentice studio, currently under design using the Figma collaborative UI design tool (https://www.figma.com/).

5.1. The Apprentice Studio

5.1.1. Introduction

The Apprentice Studio is an advanced, immersive training platform designed to facilitate the learning and mastering of traditional crafts. It is part of a comprehensive ecosystem that includes the Craft Studio, which authors and exports lessons that are then imported and executed within the Apprentice Studio. This innovative application is geared towards providing apprentices with a personalized, interactive, and hands-on learning experience, utilizing cutting-edge technology to replicate real-world crafting processes.

To ensure that everything is recorded per user a sign-in functionality has been designed. All users start their training by logging in to the apprentice studio using their assigned credentials are shown in Figure 9.

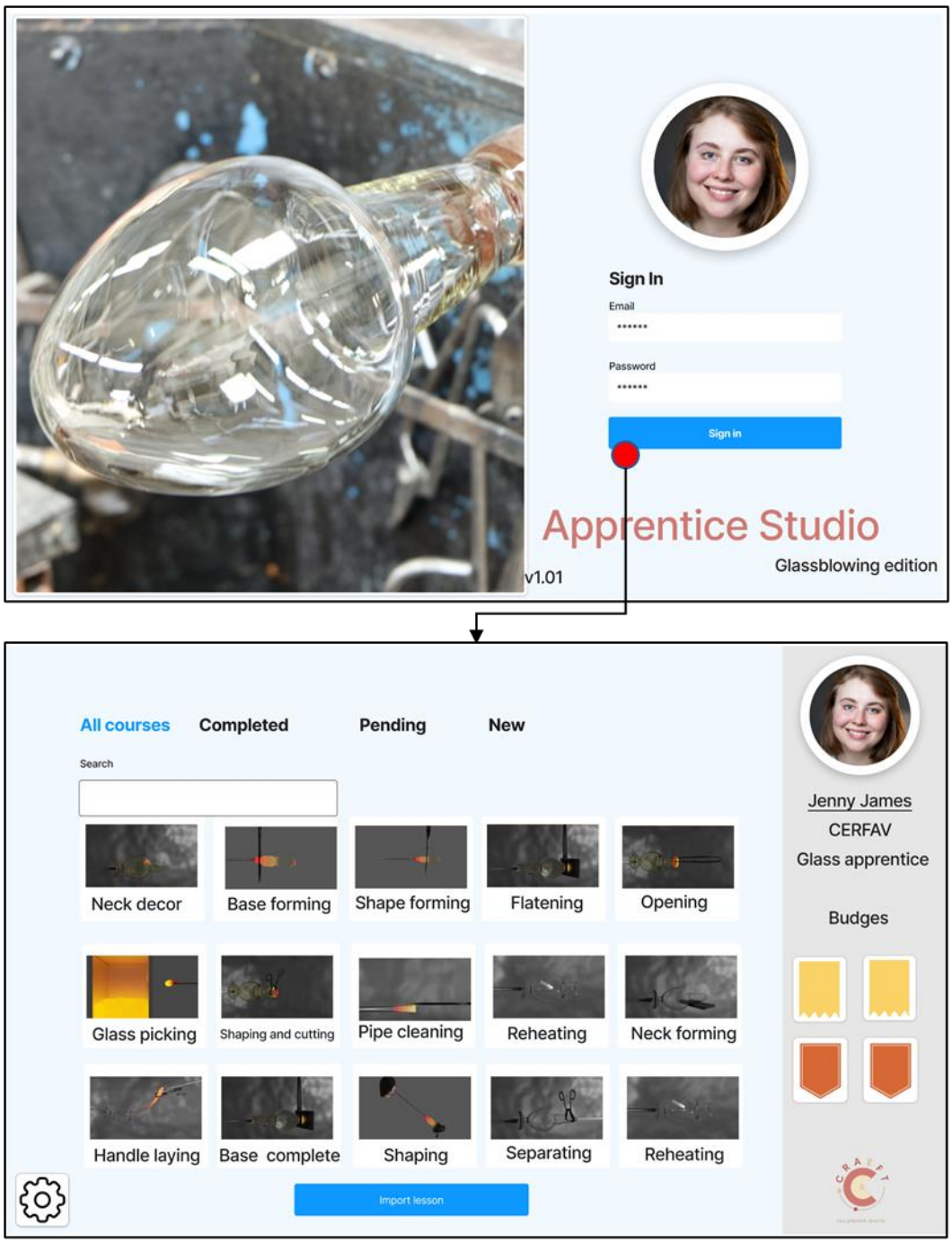

Figure 9. Signing in to the apprentice studio

When entering the Apprentice Studio, the splash screen contains the collection of courses assigned to the specific student. Initially, this is empty and waits for students to download courses from the eLearning portal and assign them to their instance of the Apprentice Studio. Courses are categorized in the following ways. All courses are on the list of courses assigned. Completed are the ones that have been completed by the apprentice while pending are the ones assigned and pending examination.

From the home page apprentices can also set up their full profile by entering their personal information as shown in Figure 10. This allows for a customized learning experience tailored to each apprentice's skills and development needs.

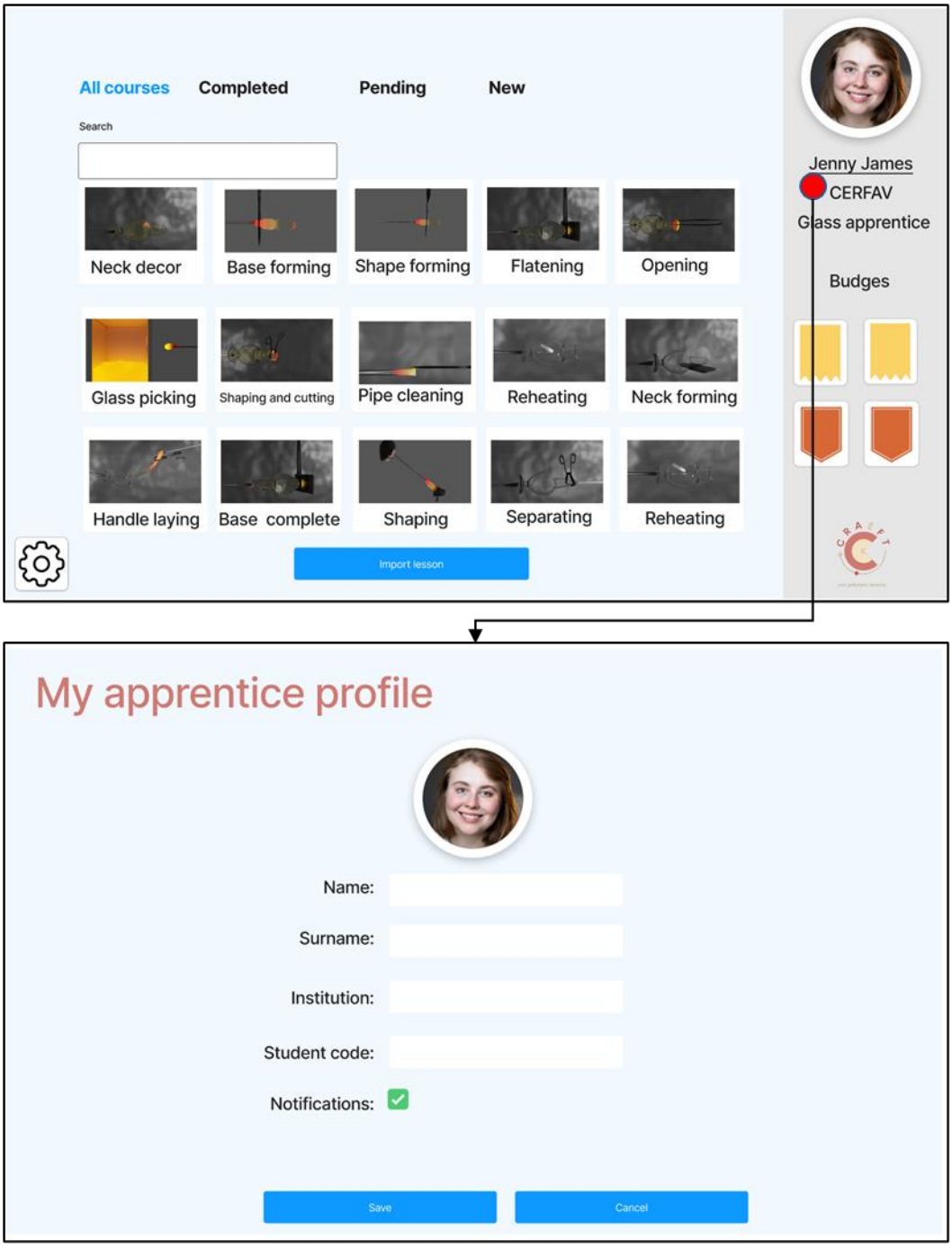

Figure 10. Editing the profile information of the apprentice

The system keeps detailed records of each apprentice's activities, completed lessons, practice sessions, and examination results. This data helps both apprentices and instructors monitor progress and identify areas needing improvement.

5.1.2. Lesson Integration

Importing Lessons: Lessons authored in the Craft Studio are exported and imported by the tutors in the eLearning portal. In the eLearning portal, Lessons are organized into a structured curriculum that guides apprentices through progressively more complex skills and techniques. This curriculum is designed to build a solid foundation before advancing to more intricate and challenging tasks. Part of this curriculum is the interactive training lessons executed by the Apprentice Studio.

Students who are taking a lesson can download the lesson specification from the eLearning portal and then integrate it into their instance of the Apprentice Studio, then import it into the Apprentice Studio. This seamless integration ensures that the content is consistent and aligned with the training objectives. The process of importing a lesson is presented in Figure 11.

When importing the lesson information is also provided on the supported by the lesson modalities. This regards the input and output devices that can be used for training such for example haptic controllers, VR headsets, etc.

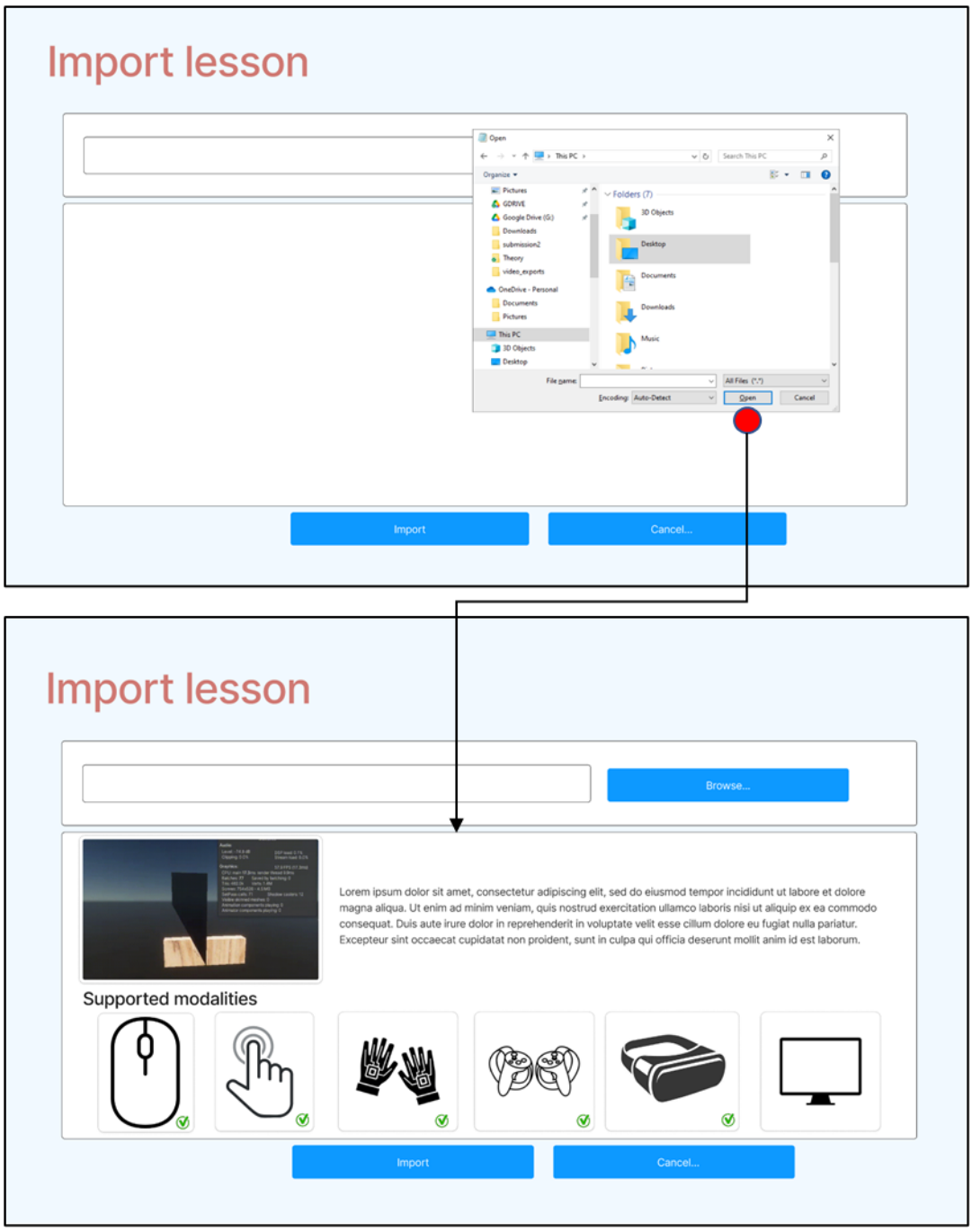

Figure 11. Importing a lesson

5.1.3. Device Compatibility

The Apprentice Studio is compatible with a wide range of devices, from standard desktop computers to advanced VR setups. This flexibility ensures that apprentices can access the training regardless of their hardware capabilities. By offering multiple modalities, the platform caters to different learning styles and preferences, ensuring that all apprentices can engage with the material in a way that suits them best.

The apprentice studio can be configured based on the availability of input and output devices per apprentice. To do so, each apprentice used the configuration interface where different devices can be activated and deactivated. The selected configurations are propagated to all the lessons that will be imported by the apprentice. Lessons that require special devices that are not available will appear as deactivated until an appropriate device is acquired and configured. The configuration process is shown in Figure 12.

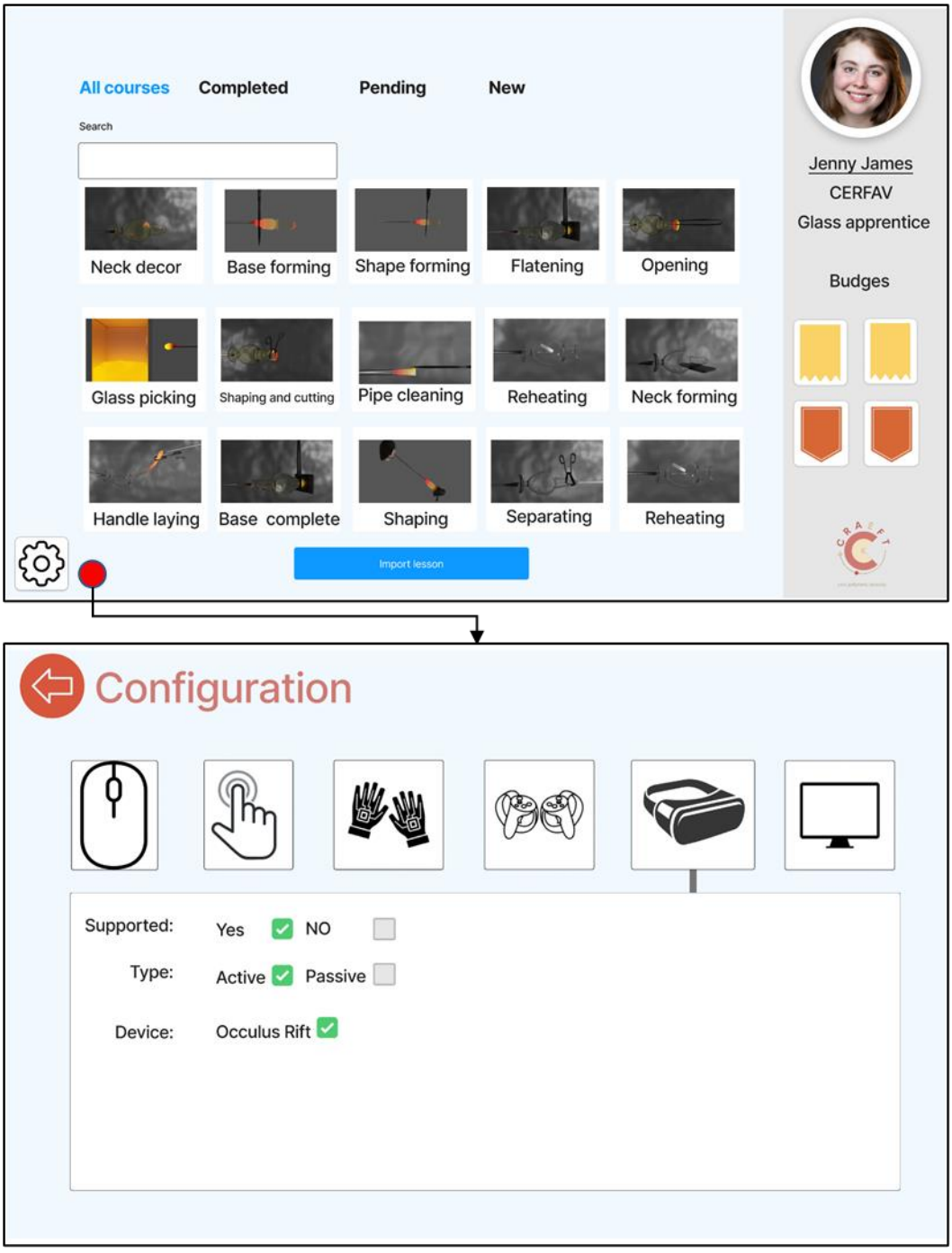

Figure 12. Configuring the apprentice studio

5.1.4. Lesson configuration

Lessons can be experienced in alternative forms based on the availability of input and output devices. The main supported modes of operation are the following:

- **3D Mode**: The lessons can be experienced in 3D on a standard computer screen, providing a detailed and interactive view of the crafting process. This mode includes interactive elements that allow apprentices to manipulate virtual tools and materials.
- **3D VR Mode**: For a more immersive experience, lessons can be experienced in Virtual Reality (VR). This mode uses VR headsets to place apprentices in a virtual workshop, providing a lifelike environment where they can practice their craft as if they were in a real studio.
- **3D VR with Haptic Devices**: To further enhance realism, the Apprentice Studio supports the use of haptic devices in VR mode. These devices provide tactile feedback, simulating the physical sensations of handling tools and materials. This helps apprentices develop a more intuitive understanding of the craft.

Figure 13 presents an example of a lesson home page. There a description of the lesson is presented together with information on what devices and modes are supported.

Before selecting the preferred mode, the apprentice needs to select whether the lesson will be executed in practice or examination mode as shown in Figure 13 bottom.

- **Practice Mode**: In practice mode, apprentices can freely explore the crafting processes without the pressure of formal assessment. This mode is designed to build confidence and competence through repetitive practice and exploration.
- **Examination Mode**: This mode evaluates the apprentice's skills and knowledge under simulated exam conditions. It is designed to test proficiency and ensure that apprentices meet the required standards for each craft.

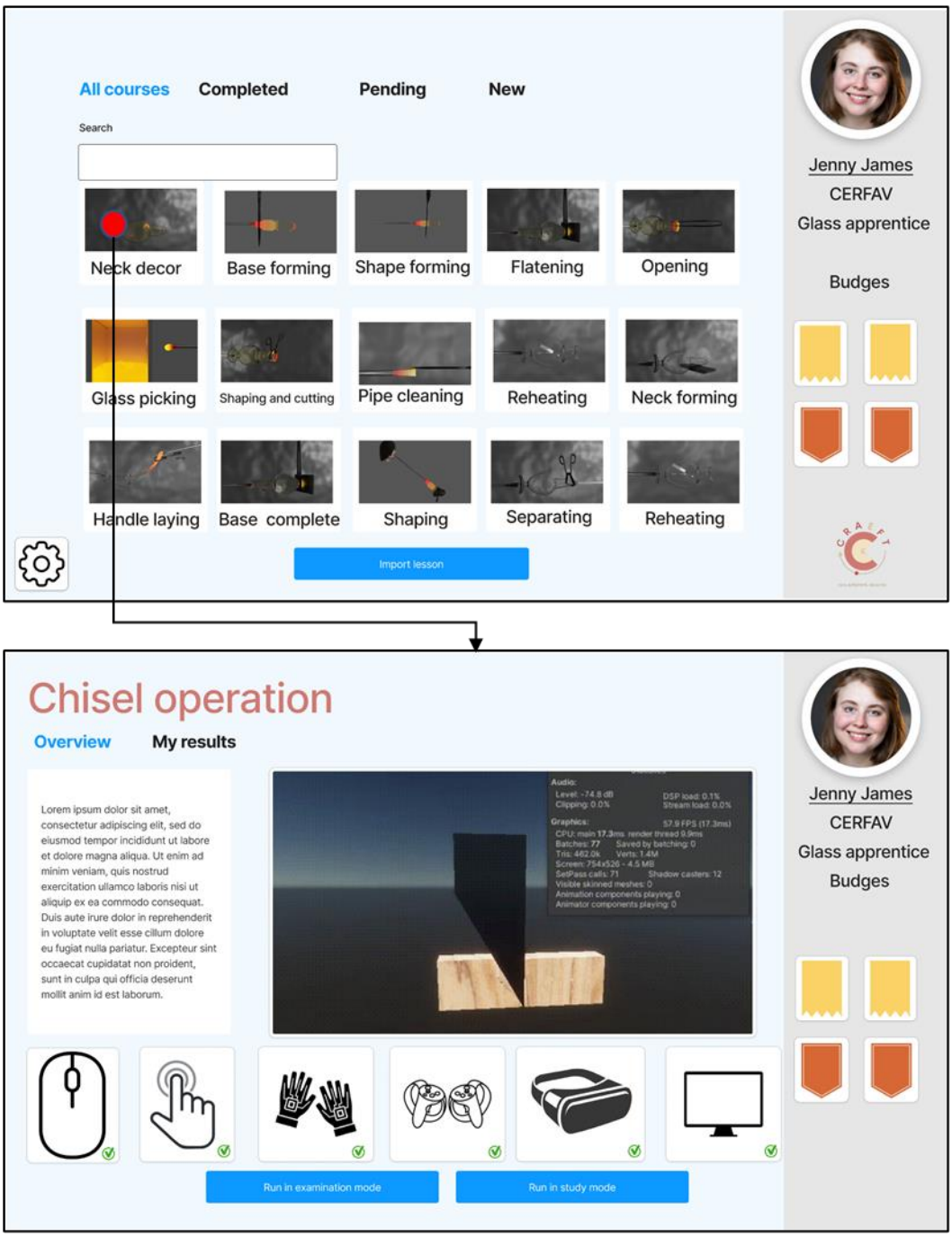

Figure 13. An example of a lesson's home page

When selecting to run a lesson in study mode first the apprentice is requested to decide upon the available modalities for the execution. From there the devices to be used for rendering the lesson can be selected before executing it as shown in Figure 14.

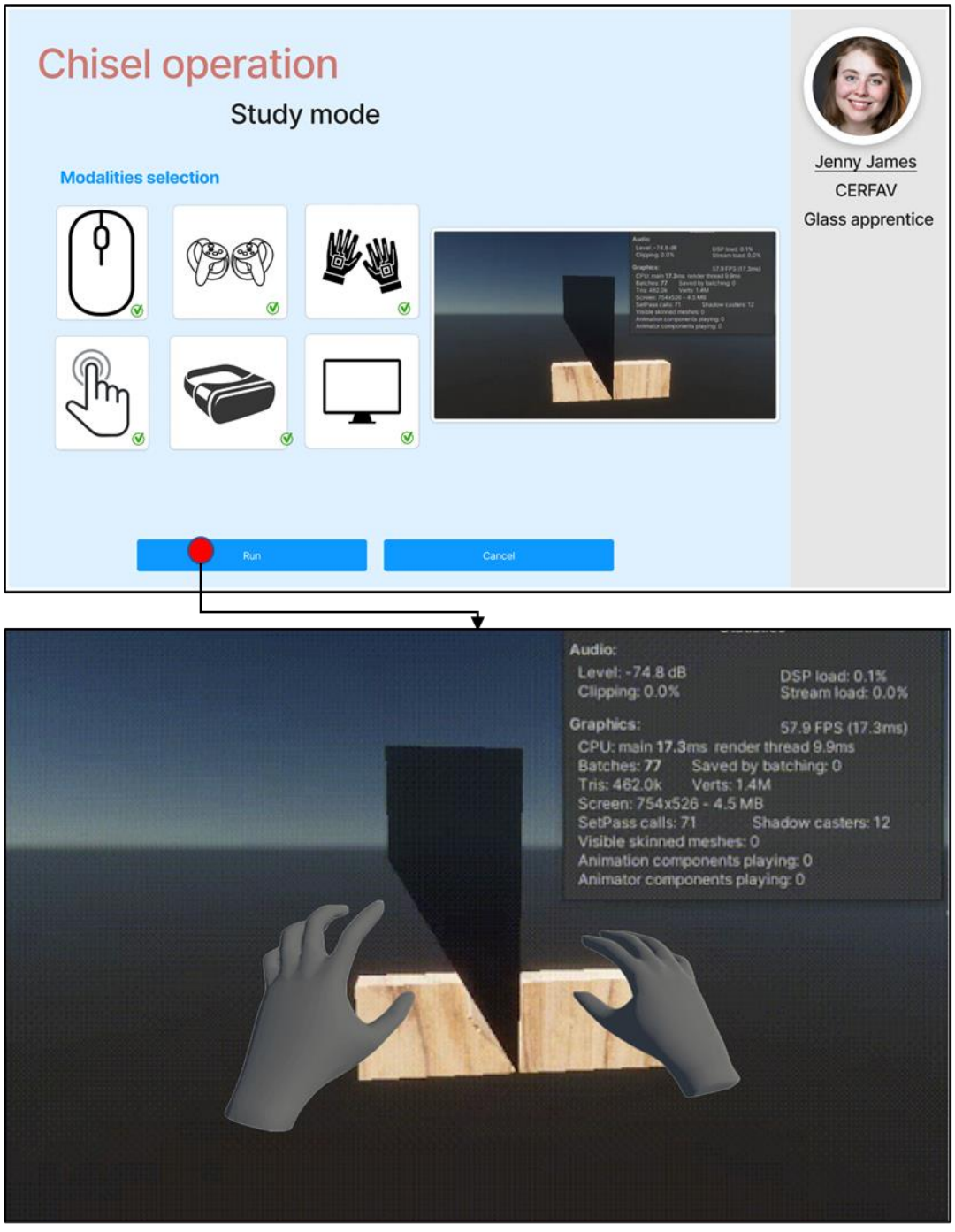

Figure 14. Running a lesson in practice mode

When selecting to run a lesson in examination mode more strict rules apply. More specifically there is a limitation on the devices that can be used for the examination since all apprentices should undertake the exams under the same conditions which are the ones defined by the tutor. Thus, the selection of modalities is locked in examination mode the exams can be taken only if the appropriate devices are available and configured on the apprentice's side. Furthermore, information is provided on the conditions that should be met for the exam to be considered successful. All are shown in Figure 15.

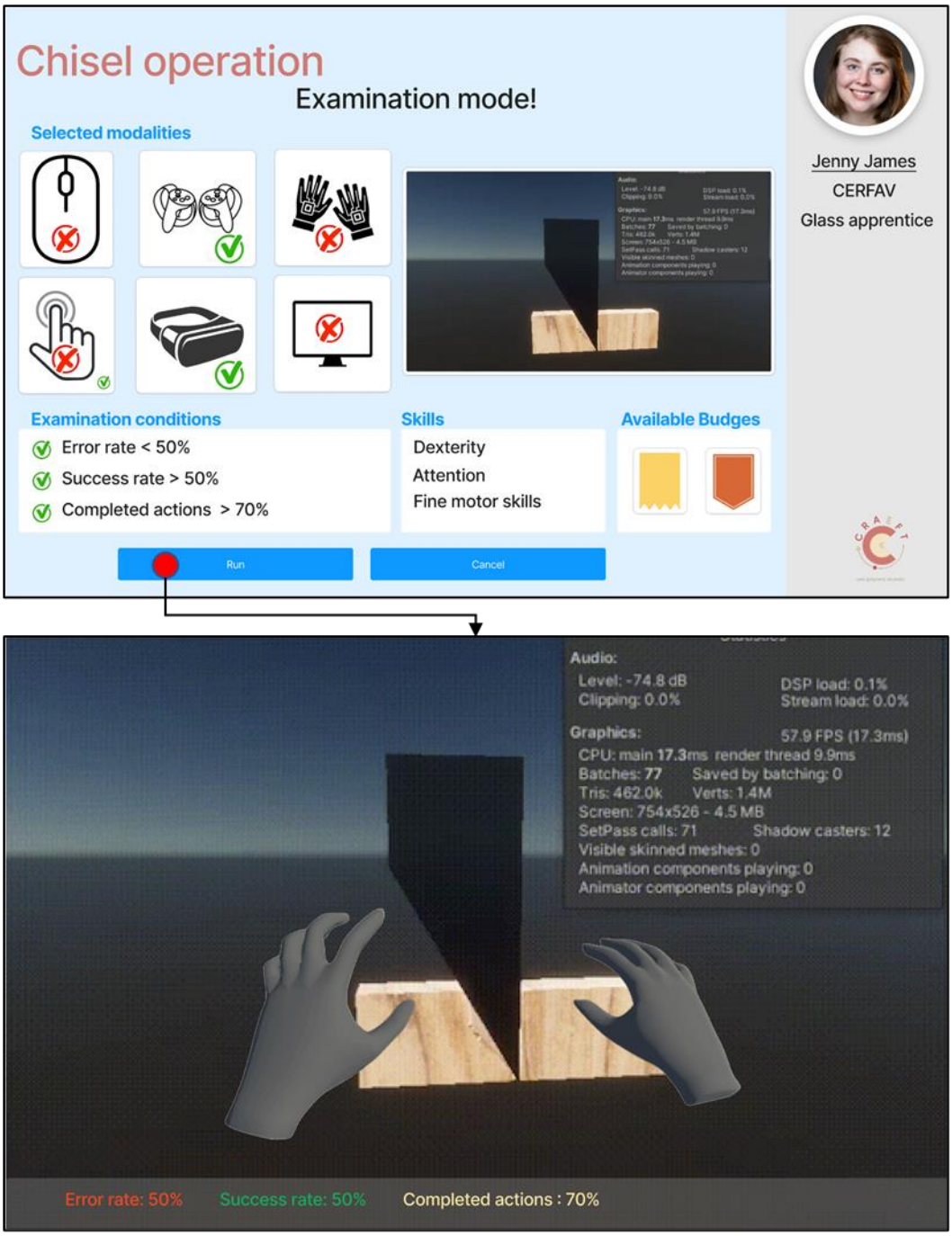

Figure 15. Running a lesson in examination mode

5.2.6. Real-World Applications

The platform's immersive capabilities simulate real-world crafting scenarios, helping apprentices develop practical skills that are directly applicable in real-world settings. The detailed and interactive nature of the lessons ensures that the skills learned in the virtual environment transfer effectively to real-world applications, making the training both practical and impactful.

6. Authoring of immersive educational content

6.1 The Craft Studio

The Craft Studio is a sophisticated and integral component of the immersive training ecosystem, tailored for craft masters to create, manage, and evaluate training lessons for apprentices. It offers a comprehensive suite of tools and functionalities designed to facilitate the design and delivery of engaging, interactive, and effective training sessions.

The overall design of the Craft Studio emphasizes interactivity and ease of use. Craft masters can quickly navigate between different sections, making it straightforward to create, modify, and review lessons and student performance. Key features include:

- **Visual Diagrams**: The use of visual diagrams in lesson creation allows craft masters to map out the entire training process clearly and logically. This visual approach makes it easier to identify and correct any potential issues in the workflow.
- **Drag-and-Drop Functionality**: The interface supports drag-and-drop functionality, enabling craft masters to effortlessly add, move, and connect components within a lesson. This enhances the flexibility and efficiency of the lesson design process.
- **Real-Time Previews**: Craft masters can preview lessons in real time, ensuring that all components are correctly linked and functioning as intended. This feature helps to verify the accuracy and coherence of the training material before it is deployed to apprentices.

The Craft Studio is designed to be compatible with a wide range of devices, ensuring that lessons can be accessed and executed across different platforms:

- **Standard Desktops and Laptops**: Lessons can be viewed and edited on standard desktop computers and laptops, making it accessible to craft masters regardless of their hardware capabilities.
- **Advanced VR Setups**: For a more immersive experience, the Craft Studio supports advanced VR setups, allowing craft masters to create and test lessons in a virtual environment. This feature is particularly useful for simulating real-world scenarios and ensuring that training material is as realistic and engaging as possible.
- **Haptic Devices**: The platform also supports haptic devices, which provide tactile feedback and enhance the realism of the training experience. This is particularly valuable for teaching skills that require a high degree of manual dexterity and precision.

Each educator accesses the Craft Studio using his personal credentials in the same way that apprentices do. This is to organize lessons per educator and allow monitoring of students, assignments, and results. Upon logging in to the Craft Studio the initial screen provided three main options. The first regards accessing all the created lessons, the second is editing processes and actions that are the components for lesson authoring, and the third regards accessing the results of lessons taken and examined by the educator's students. An overview of the home page for each educator is presented in Figure 16.

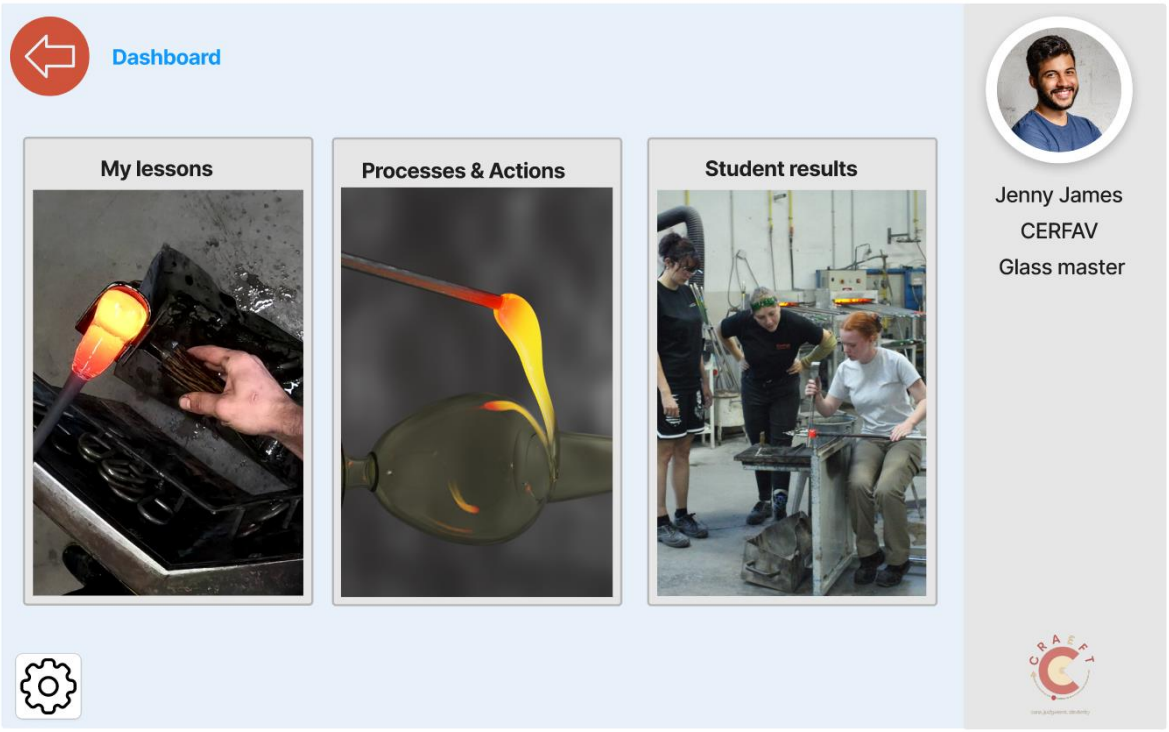

Figure 16. Home page of the Craft Studio per educator

6.2. Lessons

The **Lessons** section is the core component where craft masters can access, create, and manage their training content. This functionality includes several essential capabilities:

6.2.1. Accessing Created Lessons

Craft masters can easily access previously created lessons, enabling them to review, modify, or enhance the training material as needed. This ensures that lessons remain up-to-date and relevant to the evolving needs of the apprentices. An overview of the created lessons for an educator is presented in Figure 17.

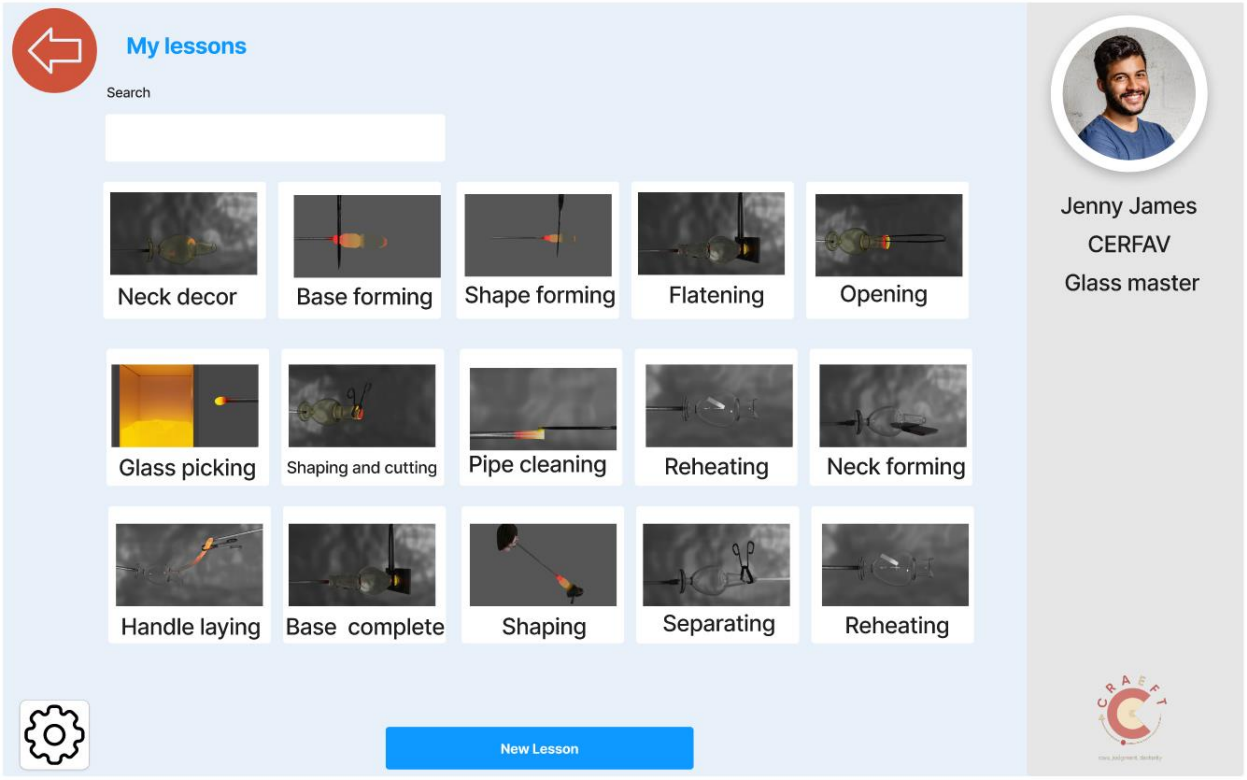

Figure 17. Overview of lessons

6.2.2. Creating New Lessons

Craft masters can develop new lessons from scratch. This process involves integrating various elements such as processes, actions, tools, machines, and workshop equipment. The creation process is facilitated by an intuitive, diagram-making metaphor, where components are visually connected using links, arrows, and other interactive elements. This approach simplifies the lesson design process, allowing craft masters to outline the sequence and flow of activities clearly and efficiently. A lesson authoring operation starts by selecting virtual processes and actions that participate in a lesson. Craft masters can import pre-defined virtual processes and actions into the Craft Studio. These processes and actions form the building blocks of the lessons and can be customized to fit the specific requirements of each craft. Each process or action can be detailed with configurable parameters, such as the devices used, input/output modalities, and the sequence of steps involved. This flexibility ensures that lessons are tailored to the learning objectives and the skills to be developed. An overview of these initial steps is presented in Figure 18.

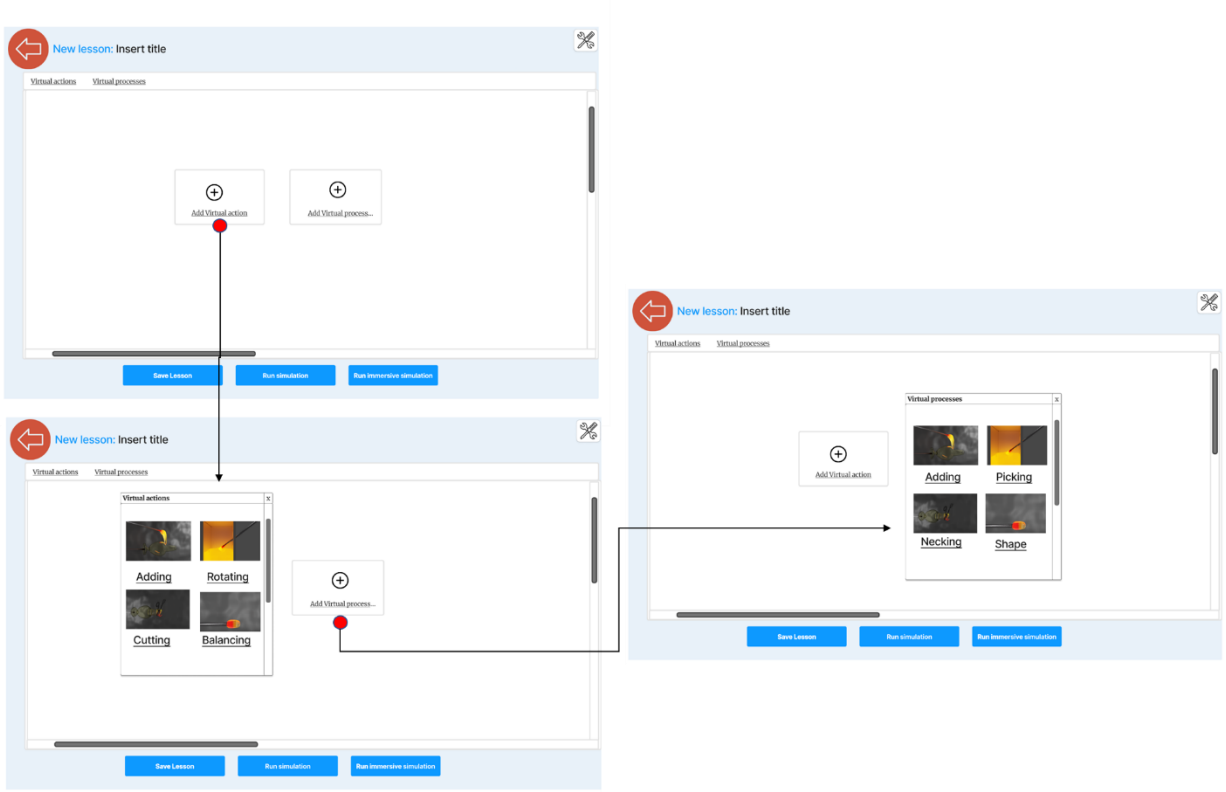

Figure 18. Starting points in lesson creation, selecting virtual actions and virtual processes

After selecting the basic components, the authoring environment is expanded with further components that can be assigned or linked to a virtual process or a virtual action. These include tools, machines, and workshop environments that are used for the initialization of the virtual actions and/or processes. At the same time, different inputs and outputs can be also assigned to the lesson regarding the devices that are available and compatible with its executions. To do so, the lesson creation interface allows for the easy linking of processes, actions, and equipment. Craft masters can visually connect these components, establishing clear relationships and workflows. This visual representation aids in the logical structuring of lessons, making it easier for apprentices to understand and follow the intended sequence of activities. An example of an authored lesson with assigned information is presented in Figure 19.

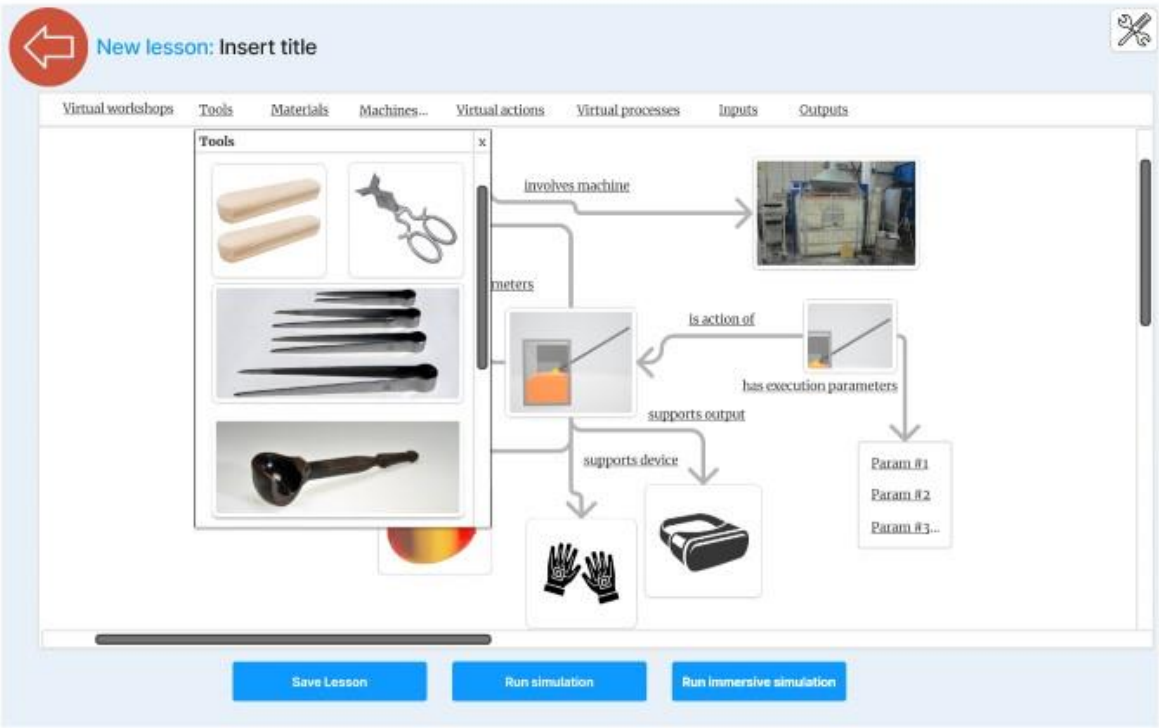

Figure 19. An example of an authored lesson with assigned information on tools, machines, workshops but also input and output devices.

6.3. Student Results

The Student Results section provides a detailed overview of each apprentice's performance across different lessons. An example of such a section is presented in Figure 20. From this section, several key operations can be done. When apprentices complete lessons in examination mode within the Apprentice Studio, they export and submit their results. This export feature captures essential data, such as the tasks completed, time taken, accuracy, and any errors or issues encountered. Craft masters can import received results from their students into the Craft Studio, where they are organized and displayed for easy access. The imported results are presented in a comprehensive format, showing the performance of each student on a per-lesson basis. This includes metrics such as completion status, score, time spent, and any feedback or observations made during the examination.

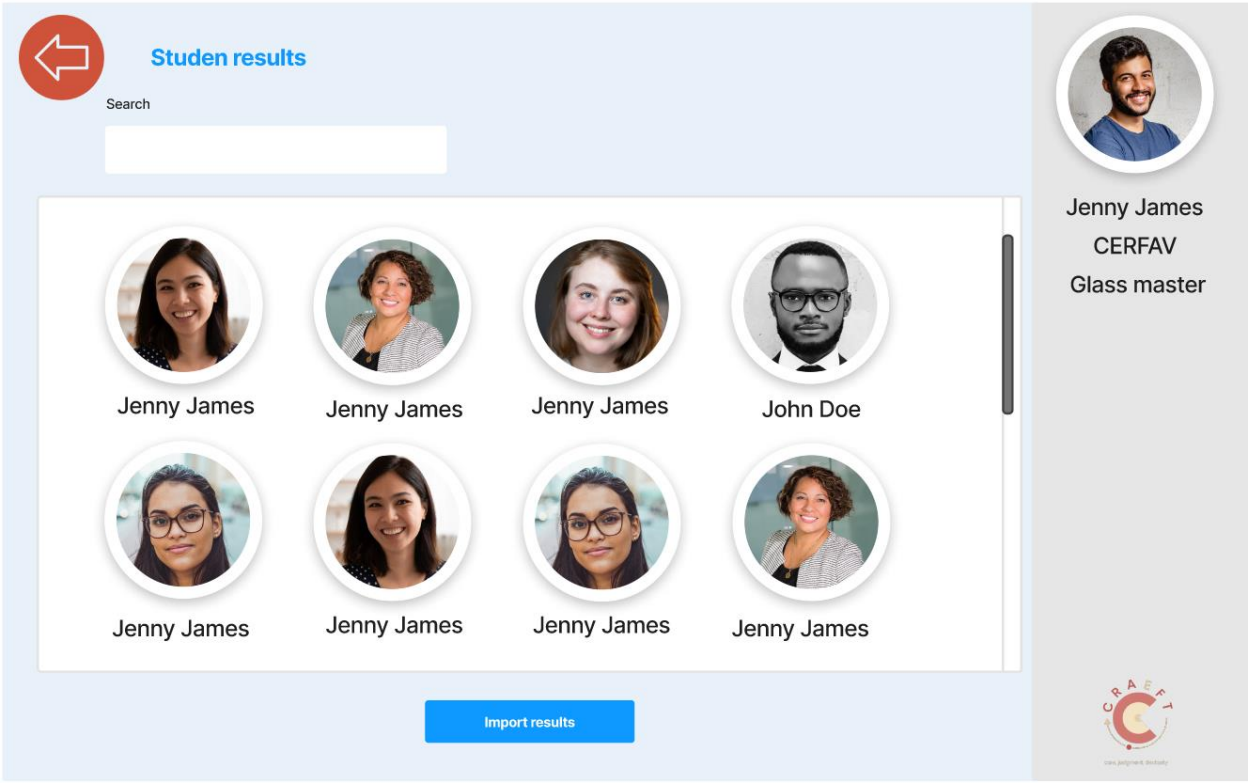

Figure 20. The students' results section.

A detailed overview of each student's progress, allowing craft masters to analyze performance trends, identify strengths and weaknesses, and tailor future lessons to address specific needs is provided by selecting each of the individual students. This analytical capability supports targeted feedback and personalized coaching, enhancing the effectiveness of the training program. An example is presented in Figure 21.

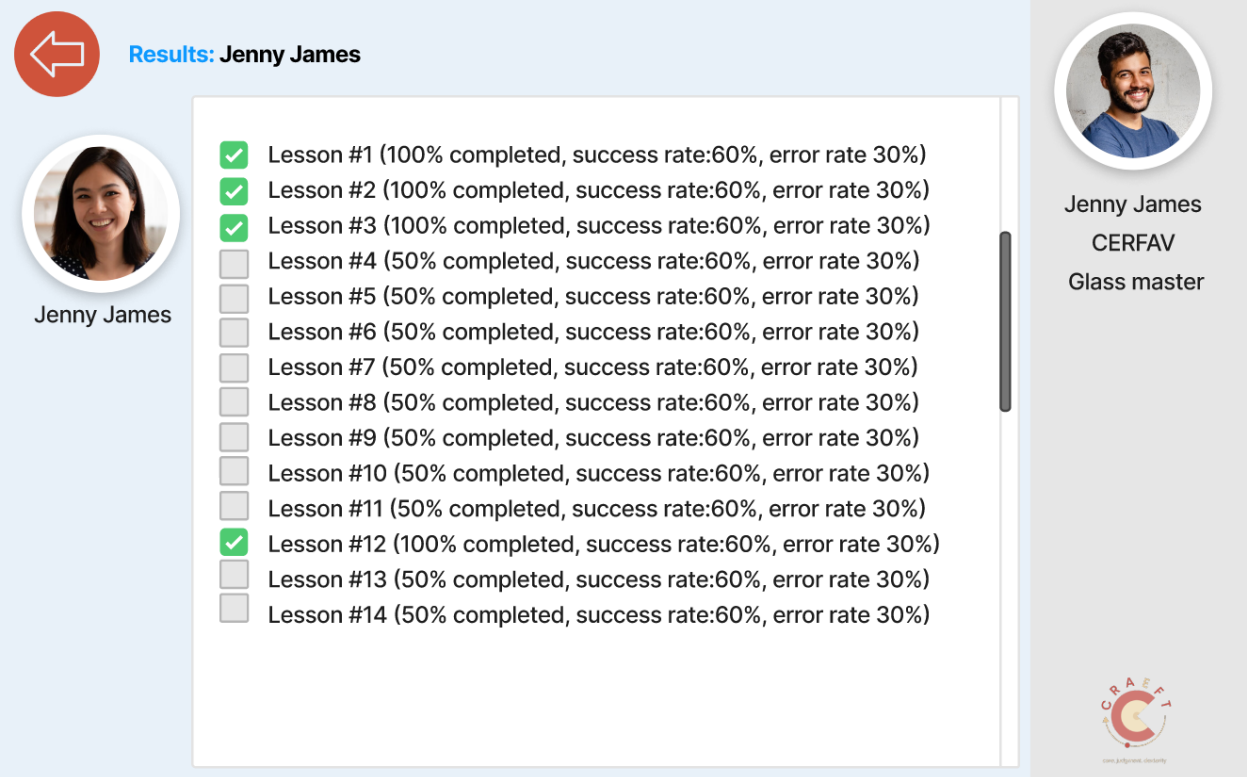

Figure 21. A student's results section.

7. Conclusions

In conclusion, in this research, the main objective was to address the pedagogical challenges inherent in craft education and training by proposing a comprehensive framework grounded in CLT. The preservation of cultural heritage and the nurturing of artisanal skills require innovative approaches to adapt to the evolving educational landscape especially when working with modern eLearning environments.

The presented guidelines, rooted in CLT principles, offer a systematic and practical approach to optimizing instructional design and content delivery within eLearning platforms. By carefully managing cognitive load, promoting active learning, and facilitating a gradual transition to digital environments, these guidelines aim to bridge the gap between the rich heritage of crafts and the opportunities afforded by contemporary eLearning technologies.

The practical demonstration of this research is conducted as part of three case studies in which the proposed guidelines are applied.

The first case study regards the authoring of eLearning courses using Moodle. The results not only demonstrate the feasibility of integrating CLT principles into existing platforms but also highlight the potential for enhanced learning experiences, ensuring the transmission of artisanal skills and cultural knowledge in a digital era. The second case study regards the design of the Apprentice studio, a virtual platform for craft training, and the third regards the design of the Craft studio which regards the creation of educational material to be executed in the Apprentice studio.

In essence, the combination of craft education and contemporary approaches, guided by the principles of CLT, can benefit the transmission of craft skills as part of our intangible cultural heritage. This research contributes to the broader discourse on innovative pedagogical strategies, emphasizing the adaptability and utility of eLearning platforms and immersive technologies in the context of crafts. In the intersection of tradition and technology, the presented framework serves as a valuable resource for educators, instructional designers, and stakeholders committed to the sustained vitality of cultural craftsmanship in the modern educational landscape.

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