The potential for using annotations to foster apprentices' visual expertise

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Abstract

The world of vocational professions relies on different types of expertise and skills, including the ability to work with a wide range of visual materials that professionals must thoroughly explore to acquire information about specific tasks. The ability to visually observe profession-specific material should be developed during the educational and apprenticeship period; however, students often struggle with acquiring this skill. Further, in higher education, there are often specific curricula devoted to training visual expertise (e.g., Ravesloot et al., 2012; Rimoin et al., 2015), but this type of highly specific training is often not offered to apprentices in vocational education.

Additionally, although research has dedicated time to study how to best train novices for white-collar professions or higher education, this research is absent in vocational fields, thus creating another gap.

The current work enters the conversation on observation with the goal of contributing to the research on vocational education and training (VET), here aiming to enhance visual expertise via cueing methods and the use of tools for performing annotations. The questions that the current dissertation seeks to answer are the following:

- *How are the visual languages of vocational professions different from each other? What kinds of visual representations and annotations are used and produced in their daily practice?*
- *Can annotations affect the way apprentices look at profession-specific images?*
- *Can annotations performed with an annotation tool in a didactic scenario promote visual expertise?*

To achieve this desired aim, the current thesis starts with an exploratory first study aimed at investigating the visual languages of different vocational professions to identify the wide range of visual representations (e.g., drawings) and annotations used and produced by professionals in these fields. This was a necessary first step to understand the richness and diversity across professions. For

this reason, 11 different professions from the craftsmanship, industrial, health, and services sectors were included. From the results of the first research study, we identified professions that rely on visual material and expertise. The fashion design profession stood out for its extensive use of representations, such as photographs or technical drawings, and for its curriculum, which already integrates some visual expertise exercises. The second study revolved around the potential of conveying a ‘professional way’ to look at profession-specific images using annotations (or cues). The current study was necessary to understand whether annotations could be used as an attention-guiding method and influence where apprentices looked in the images. After the positive results of this research, a third study was carried out with beautician apprentices who, also rely on visual expertise (e.g., identification of skin anomalies). This study involved an educational scenario co-constructed with teachers, where apprentices completed a six-month visual expertise’ training with images depicting skin anomalies on Realto.

Data from the three studies were collected using a wide range of quantitative and qualitative methods, including semi-structured interviews, focus groups, surveys and questionnaires created specifically for the research, verbal and written descriptions of the visual material, and gaze data collected via eye-tracking.

The findings of the first study indicate that the 11 professions considered in the study possess a great variety of visual languages, from which many types of visual representations emerge (e.g., renderings, sketches, photos) and annotations (e.g., symbols, diagrammatic elements). The second study indicates that annotations direct students’ gazes (as measured using eye-tracking) towards relevant parts of profession-specific visual material (e.g., central sections), in this case, depicting garments (e.g., shirts).

The third study indicated the importance of promoting visual expertise in apprentices. The results confirmed the impact of annotations in directing students' attention toward the relevant parts of the image (of skin anomalies) and their ability to assist the observation process by helping apprentices identify relevant details such as texture, colours, and so forth. Moreover, the study highlighted the importance of annotation technologies in studies on visual expertise.

Through these results, this doctoral thesis concludes that the investigation of visual languages is necessary to provide the best training for future professionals entering the numerous professions that rely on visual material and that annotations can be used to train apprentices' gazes. This could be exploited for many training purposes across different professions with both experimental designs and scenario-based interventions within the classroom.

List of the publications composing this thesis

Coppi, A. E., Cattaneo, A., & Gurtner, J. L. (2019). Exploring visual languages across vocational professions. *International Journal for Research in Vocational Education and Training (IJRVET)*, *6*(1), 68–96.

Coppi, A. E., Oertel, C., & Cattaneo, A. (2021). Effects of Experts' Annotations on Fashion Designers Apprentices' Gaze Patterns and Verbalisations. *Vocations and Learning*, *14*(3), 511-531.

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1 Introduction

The professional world is constantly evolving, and education must stay relevant by teaching students a wide range of transversal skills (Pang et al., 2019). To become and remain competitive in the professional world, it is important for students to acquire different life skills, and, within the long list of needed skills, there are some, such as visual expertise, that are cognitive and perceptually oriented and that are directly connected to specific tasks in the profession. These skills are fundamental in many professions, such as radiology (e.g., O'Halloran & Deale, 2006; Jasani & Saks, 2013; Naweed & Balakrishnan, 2014; Kok et al., 2017). In addition, developing visual expertise is fundamental for many medical professions, such as radiology (e.g., Ravesloot et al., 2012), dermatology (e.g., Eapen et al., 2020) and ophthalmology (e.g., Gurwin et al., 2017), but it is also important for many other fields, such as architecture (e.g., Styhre & Gluch, 2009) and others like sports (e.g., Mitroff et al., 2013). However, the research on visual skills in these professions is well documented and universities have also developed extensive training courses to increase observation among novices (e.g., Rimoin et al., 2015; Kok et al., 2015).

Despite the lack of studies on vocational professions and the fact that training efforts have been mainly carried out in higher education (and within the white-collar professions), the need for more specific training methods for apprentices is still felt by both practitioners and students. For apprentices, acquiring visual expertise is fundamental because apprentices must be able to understand and work with the complex visual language of their own profession, as well as the languages of related professions.

A profession’s visual language can be extensive and may comprise many different visual representations such as technical drawings, sketches, or photographs that contain relevant information about the task, such as information about the client, representation of a feature, measurements, details, and step-by-step procedures. Because of the complexity that apprentices must acquire, vocational teachers perform some activities directed at fostering visual skills, but the amount of time spent on this topic is limited compared with other professions that have dedicated curricula. This generates a gap between the knowledge that apprentices acquire during their education and the knowledge that they should possess when they enter the workplace. For instance, a beautician who cannot recognise skin anomalies might perform the wrong treatment, causing damage to the skin, and a fashion designer who cannot identify the main features of a shirt might end up creating the wrong pattern and, consequentially, a badly constructed garment (Caruso et al., 2019).

At the theoretical level, the present thesis contributes to the literature on the use of cueing to foster visual expertise of visual material, as well as research on visual languages and visual expertise. At the educational level, this thesis contributes to the implementation of educational scenarios aimed at fostering visual expertise through annotations offered by Realto, a platform developed by the Leading House Dual-T: Technologies for Vocational Training.

The below paragraphs will elaborate on the importance of fostering visual expertise in vocational professions and will then review the literature surrounding visual expertise, gaze, and the use of eye-tracking in research. Next, the literature review will focus on the use of annotations as a cueing method and its potential to direct the gaze. The theoretical section will conclude with examples of annotation tools and a presentation of the Realto platform. Finally, a summary of the three articles is presented, along with a discussion of the main findings and implications.

2 Theoretical Framework

2.1 Visual languages and the relevance of visual expertise in the professional world

The concept of visual language that applies in this study includes the idea of visual practices. Such practices, are performed by professionals working in a variety of occupations where such activities as coding, highlighting, and producing visual material central to their work. Visual practices are not universal but context-bound, with different visual practices being produced, used, and actualised in different professional domains and even in different activities of a focal domain (Goodwin, 2004).

For the purposes of this study, the visual material that professionals use, and produce is based on the concept of visual representation, which is the depiction of visual information. Professionals use a great variety of representations in their work. For instance, engineers employ a complex taxonomy (with many subsets) of representation in the form of sketches, drawings, models, and prototypes, (Pei et al., 2011). Geographers (Yates & Humphries, 1998) generate different types of schemas, such as maps of cities or kind of maps that illustrate the relationships between locations. Radiographers (Hartswood et al., 2002) who work with mammograms use capture sheets to report information, such as the location of cysts, presence of pain, issues in reading the scans, and diagnostic options. Architects produce sketches and then generate CAD images and full-scale models (Styhre & Gluch, 2009). Another example is fashion designers, who work with a wide range of representations and spend a considerable amount of time producing and refining their technical drawings, which are called patterns (Caruso et al., 2017). Even dermatologists work with magnified photos called dermoscopies, which depict skin anomalies. These images are often annotated to further identify the main features of the anomaly and to help decide whether they are benign or not (Ferreira et al., 2012).

The above are a few examples of the visual languages being produced and used in various professions. However, it is necessary and important to explain why visual expertise is fundamental and should be fostered in novices.

Being able to observe and understand visual material is essential for many workers; for instance, gardeners must work not only with planimetries but also photographs, sketches, drawings, and renderings. This is also true for carpenters, winemakers, and many other occupations. Visual materials are often 'perceptually complex,' and it is essential for workers to develop high-level observation abilities to 'read' such materials properly. The importance of visual expertise was emphasised by Lehtinen et al. (2020) who pointed out that researchers have identified many of the processes involved in learning. These processes include memory, problem-solving, and knowledge restructuring, as well as the role of intensive, high-level training and perceptual elements. This indicates that there are elements beyond mere procedural and declarative knowledge that determine essential expertise for novices. In fact, some professionals, such as radiologists, meteorologists, and air traffic controllers, spend most of their time observing visual materials and making decisions mainly based on what they see (Gegenfurtner et al., 2019).

The importance of visual expertise was also discussed by Kellman and Krasne (2018), who pointed out that education has overestimated the importance of declarative and procedural knowledge among experts while diminishing the role of perceptual learning or visual expertise in the successful performance of many professional tasks. In fact, the authors indicated that many students who focus on mastering declarative knowledge fail to recognise biological structures in professionals' visual material.

2.2 Theories, processes, and mechanisms that allow for the acquisition of visual expertise

The numerous points of view, frameworks, theories and designations that have been used pose a challenge to the production of new knowledge in the field of visual expertise (observation or visual cognition). In other words, researchers' understanding of how professionals interpret visual materials is framed by the epistemological perspective they adapt in their conceptualisation of visual perception (Gegenfurtner & Van Merriënboer, 2017). For instance, observation can be seen as a social construct mediated by the tools, people, and discourses of socially organised practices (Goodwin, 2004). Observation can also be viewed as a physiological activity that is accomplished in the human mind in response to sensory input (e.g., Brunyé et al., 2019; Gegenfurtner et al., 2017; Seidel & Stürmer, 2014).

Because of the complexity of the research in this area, this study will narrow down refine the presented literature to the concepts of perceptual learning (PL) (e.g., Kellman & Krasne, 2018). I will mainly cite studies that deal with the cueing and the enhancement of observation, focusing on the radiology (e.g., Kok & Jarodzka, 2017) and dermatology communities (e.g., Ko et al., 2019).

Various definitions of perceptual learning (PL) are in use. For instance, PL has been described as 'any relatively permanent and consistent change in the perception of a stimulus array, following practice of experience with this array' (Gibson, 1963, p. 29). Goldstone also considers PL as processes that 'involve relatively long-lasting changes to an organism's perceptual system that improve its ability to respond to its environment and are caused by its environment' (1998, p. 587), while Seitz described PL as 'how experience can change the way we perceive sights, sounds, smells, tastes and touch' (2017, p. 631). In Gold and Watanabe's definition, 'perceptual learning is experience-dependent enhancement of our ability to make sense of what we see, hear, feel, taste or smell. These changes are permanent or semi-permanent, as distinct from shorter-term mechanisms like sensory adaptation or habituation. Moreover, these changes are not merely incidental but rather adaptive and therefore confer benefits, like improved sensitivity to weak or ambiguous stimuli' (2009, p.1).

What all these definitions have in common is that the concept of 'change via experience,' is regarded as the foundation for the development of visual expertise, especially in the professional world. The question is how this change occurs. In observation-related professions such as radiology, novices must master the process of discriminating subtle differences in light and shadow that allow for the extraction of meaningful image features (Seitz, 2007). Jewellers or airport baggage security officers rely on visual tasks to discriminate and make decision. These professionals can do so because repeated exposure to stimuli during training has affected their perceptual and sensory abilities, causing a neural reorganisation in the brain (Yotsumo and Watanabe, 2008). This phenomenon is known as 'neural plasticity'. Generally, PL involves the area of the neocortex extending upstream into the primary cortex along the visual pathway from the temporal lobe. Plasticity indicates experience-dependent alteration of pre-existing sets of connections that happens by functional or morphological (Gilbert et al., 2001). If these changes are caused by limited experience, they are generally temporary while if the interaction with a stimulus become long term, the 'rewriting' of the cortex remains.

The above brief exploration of how PL occurs allows for the model of PL that has been developed over the past decades to be examined in greater detail. This is a challenging task because there is no unified or widely accepted model of PL, as mentioned above in reference to the concept of 'visual expertise' (see Gegenfurtner & Van Merriënboer, 2017). The reason is that researchers from different theoretical perspectives approach the problem differently: some focus more on defining an architecture of the visual processing involved in PL, while others focus directly on the specific mechanism of the process and its effects.

For instance, their theoretical models deal mainly with the physiology and perceptual perspective and describe a visual process that occurs in different cortical stages due to the feature of the stimuli, type of task, and exposure to the task (Yotsumoto and Watanabe, 2008). In this perspective, three models categorise information in a hierarchical way. The 'local network model' indicates that early processing of the neural reorganization takes place mainly in the low-level cortex, where visual signals are projected (see Adini et al. 2002; Tsodyks et al. 2004). Mid-level stage learning occurs by reweighting the neural connections between early stages where local processing has occurred; these changes occur in the neural connections specifically for a given task (Dosher and Lu, 2000). The Reverse Hierarchy Theory indicates that learning is an attention-guided process that starts in high-level areas that may be able to deal with tasks requiring discerning between signals with large differences, but when a task necessitates discrimination of signals with smaller differences, the site of learning proceeds to lower visual areas where signals with smaller differences can be discerned (Ahissar et al., 2004).

Further, other models focused on the different processes and effects that allow the brain to progressively configure information extraction in any domain to optimize task performance. Kellman (2002) proposed a model of PL where a series of effects are categorised into two groups:

- *Discovery effects* entail identifying what information is relevant to a domain of classification; humans discover and obtain information related to the task or classification and ignore irrelevant info. They can then extract information in large chunks, forming and processing higher-level units and discovering relationships. People thereby become more sensitive toward stimuli that they previously ignored and begin categorizing elements of the perceived world.

- *Fluency effects* involve obtaining extracted information with greater ease and speed. With practice, humans can learn to classify elements through a fluent and, ultimately, automatic process, with little or no sensitivity to attentional load. The consequence is that perceptual expertise may lead to more parallel processing and faster information acquisition.

Discovery effects	**Novices**	**Experts**
Selectivity	Attention to irrelevant or relevant information	Selective pickup of relevant information Filtering/inhibition of irrelevant information Larger chunks Higher-order relations
Units	Simple features	
Fluency effects		
Search type	Serial processing	Increased parallel processing
Attentional load	High	Low
Speed	Slow	Fast

Table 1. Discovery and fluency effects in novices and experts (Kellman, 2002)

Diverging from other authors, Goldstone (1998, 2013) believed that PL is not a unitary process but is itself sustained by four different mechanisms:

– *Attentional attuning:* Attention can be selectively directed towards important stimuli at different stages of information processing. With the shift of attention, some categories have more impact than others, and an improvement in perception occurs through ignoring some elements and paying attention to others, as shown in the studies on target-distractor discrimination.

- *Attribute differentiation*: Through this process, stimuli that were once viewed as a whole become separated and viewed as single units, such as the differentiation of sound in a language.
- *Unitisation*: This is the opposite of differentiation and involves the construction of single units when the complex configuration of visual stimuli is viewed. Therefore, a single unit is needed to view the whole. This can be explained by the missing-letter effect in reading, in which humans show the ability to identify a word even though they read only part of it.
- *Stimulus imprinting*: Through imprinting, detectors (also called receptors) that are specialized for stimuli or parts of stimuli are developed. The term imprinting captures the idea that the form of the detector is shaped by the impinging stimulus. The imprinting might be of the entire stimulus or parts or features of it, but there is also another level that is more abstract where, rather than developing detectors for a particular stimulus or features, environmental regularities that span across a set of stimuli can also be internalised.

Other authors have studied PL directly in their own field of expertise; for instance, in dermatology, some authors have conceptualised perception with a two-system approach. The first involves automatically gathering information that can be described using Gestalt's principles, while the second includes the use of checklists, memory, algorithmic knowledge, and lists. Using the first system, dermatologists can 1) recognise anomalies even if they see a part of it (unilateral and clustered symptoms), 2) group objects close to each other (e.g., the simultaneous presence of telangiectasia, papules, macules, and hypopigmented areas are a manifestation of Goltz syndrome), 3) identify anomalies by a specific colour (e.g., erythema can vary from light pink to red) and 4) separate healthy from unhealthy skin (figure separation). The second system uses high-level processing, which is characterised by mnemonics, algorithms, a checklist, and a list of diagnoses (Ko et al., 2019). In radiology, Waite et al. (2019) reflect on professionals' medical image analyses indicate that it is a process that involves four stages of visual inspection: 1) identification of the object of analysis, 2) recognition of relevant sections of images, 3) identification of target sections (e.g., lesions), and 4) diagnosis.

These numerous models are just a small portion of the massive work in PL that extends to many different areas that approach the concept with different viewpoints and depths (e.g., neurobiology, neuroscience).

The complexity of some of these fields is beyond the scope of the current work in education and science; therefore, only some of the theories and mechanisms presented above have been evaluated for the design of Studies 2 and 3 and were also used to prepare tasks and materials.

2.2.1 Visual expertise and gaze

Studying the differences in visual expertise between experts and novices has been the focus of numerous works and fields. For instance, in sports, scholars have noticed that expert gymnastic coaches show fewer but longer fixations on athletes' bodies compared with novice coaches (see Moreno et al., 2002); similarly, swimming coaches spend more time fixating on swimmers' movements (e.g., body-rolls) and specific body parts (e.g., hands and head) when the swimmer is entering the water compared to their novice colleagues (Moreno et al., 2006).

In biology, Jarodzka et al. (2010) indicated that in a fish locomotion task, novice biologists exhibited longer viewing times on irrelevant areas while experts exhibited longer gaze durations on the fishes' relevant features, providing better descriptions of the images viewed.

Gaze tracking has also become relevant in teaching with studies that attempt to understand more about the interactions between students and teachers, as well as the visual expertise of the teachers during the lesson. In one study, experienced teachers observed class interactions by visiting and revisiting specific areas, gazing at students' bodies and at sections of the class with more physical and verbal interactions between students when compared with inexperienced teachers (Wolff et al., 2016).

Another main field is the medical one, with most visual studies being conducted in radiology. For instance, Krupinski (2006) noticed that experts tend to fixate on areas of high saliency and have longer fixations compared with novices, while students generally enact prolonged saccades (scanning) on the entire image. Additionally, Wood et al. (2013) found that experts are quicker than novices in identifying fractures and spend more time fixating on them. In addition, experts draw conclusions based on observed abnormalities instead of focusing directly on procedural knowledge (Jaarsma et al., 2014).

Another related field is dermatology. Krupinski et al. (2014) trained dermatologists in reading benign and malign close-up dermoscopy (high magnification images), showing that a dermatologists tend to have a more efficient search with fewer fixations and longer dwelling time ('one visit in an area of interest, from entry to exit') (Holmqvist et al., 2011, p. 190).

In general, regardless of the vocational field, and aside from some minor exceptions, experts and novices seem to differ in the way they explore professional-specific images. It can be concluded that experts rely on three main elements when inspecting an image compared to novices:

- Quickly identify task-relevant areas or details of the image.
- Spend more time observing relevant features (e.g., fractures in an X-ray) and less time observing irrelevant ones (e.g., tender tissues in an X-ray).
- Show higher content evaluation, understanding of the images viewed, and ability to describe the images in a comprehensive manner.

2.2.2 Measuring visual expertise

The idea of using one's eyes to acquire information about the cognitive status of a person involved in a cognitive task is not new; the first attempt at recording gaze dates back to the late 1800s and early 1900s. In this case, the 'tracking' was very different from current methods, and the procedures and tools were directly built by the researchers. Initial approaches to gaze tracking involved the use of cocaine to slow down eye movements and a metal ring to identify the position of the eyes (Delabarre, 1898), and later, the use of photography (Dodge & Cline, 1901). Much later, researchers used special contact lenses (Yarbus, 1967) and videos (Crane & Steele, 1985).

The biggest innovation came with the creation of the first company, Applied Science Laboratories, in the 1960s and 1970s, which produced the first modern eye tracker on a large scale. The technology was later used by some universities. From that point on, the technology evolved to different models of computer-based eye trackers that gradually increased their quality with higher sampling rates, simpler technology, more flexibility during testing, and more ad-hoc software to create the stimuli and perform extraction and data analyses.

The benefits of using eye-tracking in research in instructional design and education include triangulation between quantitative and qualitative measures, the possibility of modelling eye movements for novices, and the identification of differences between experts and novices while observing visual material. In the first case, Jarodzka et al. (2017) pointed out that the use of eye-tracking in instructional design allows researchers to learn about experts and novices during a wide range of visual tasks. Moreover, eye tracking can be used to triangulate data and combine both quantitative and qualitative measures (e.g., think-aloud protocol). For instance, the authors presented material with text, images, and video to the participants, and eye-tracking helped in understanding that pupils ignored all of the information that participants deemed irrelevant in the images, even if the material was created using the main principles of multimedia learning. Furthermore, eye tracking is used to identify the differences between novices and experts and to cue the gaze of novices. These topics will be explored in the following paragraphs.

2.2.2.1 The eye and the eye tracker

The human eye lets light come in through the pupil and then turns the image upside down in the retina, where light-sensitive cells called rods and cones translate the light into electrical signals that are sent through the optic nerve to the cortex for processing. Another important structure for human vision is the fovea, where cones are overrepresented; this results in the full acuity of the eye not being equally distributed in the retina. This means that humans have acuity in only a small area of the retina, so to see a larger object in the visual field, humans must move their eyes so that the light enters into the fovea and the cortex can process a magnified image (Holmqvist et al., 2011). The functioning of an eye tracker relies on the tracking of the pupil; the tracker emits a near-infrared light directed at the pupils, causing reflection in the cornea. These corneal reflections—the vector between the cornea and pupil—are tracked by an infrared camera (Fig. 1).

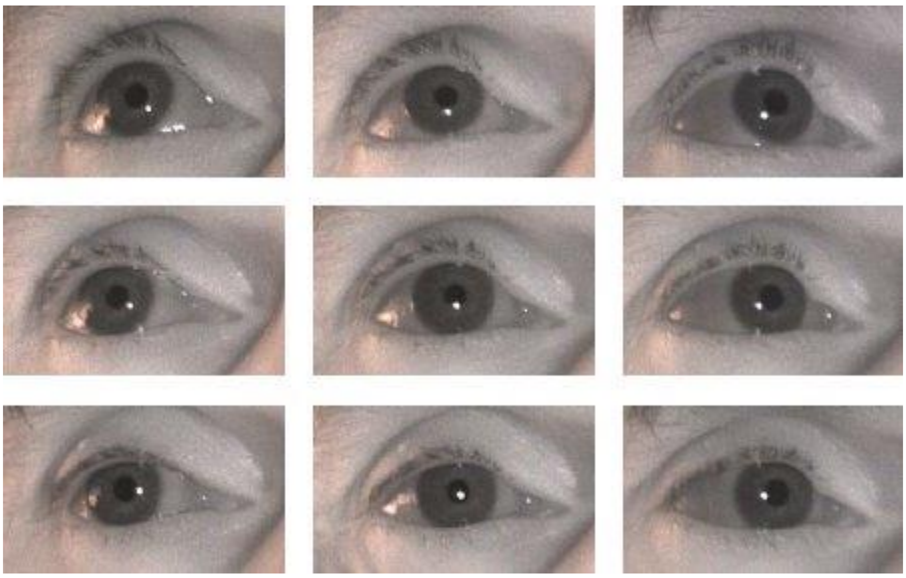


Fig. 1 - Corneal reflection at various gaze positions (Blignaut, 2014)

Human eyes are controlled by three different muscles that allow horizontal (yawn), vertical (pitch), and torsional (roll) movements to be controlled in three dimensions (see Schneck, 2010). The eye tracking records the following movements:

- *Saccadic movements* or saccades are defined as the fastest movements humans can produce. They comprise the movements of the eyes between fixations in the same direction (Cassin et al., 1990). Saccadic movements can be voluntary, like when reading, or involuntary. They last for about 30 to 80 ms, and when they stop, they produce a wobble movement called glissades that last for another 10 to 40 ms.
- *Fixations* happen when the eye remains relatively still over a certain period; these non-movements can last from a few ms to several seconds (Holmqvist et al., 2011). However, the eye is not completely still during fixations and can still produce movements called micro-fixations, tremors, or drifts. Fixations are calculated via gaze points; if an eye tracker had a sampling rate of 60 Hz, then the gaze points collected are 60 per second. If the gaze points collected are close in terms of space and time, then this gaze cluster constitutes a fixation.
- *Smooth pursuit* comprises the movements used to stabilise the image of a moving object (Schulmann et al., 1987).

From these few movements, more than 100 measures have been derived (Holmqvist et al., 2011), which can be divided into measures of movements, position, numerosity, latency, and distance. Some of these measures, such as fixation durations, can be extracted directly from the software, while others, such as gaze coverage, need extensive cleaning from the raw data using scripts (see the appendix).

2.3 Annotations and their use as a cueing method

The first part of this chapter takes on the challenge of exploring the main theories of multimedia learning, which are at the base of the idea of using annotations (cues) to improve novices' cognitive and perceptual abilities. It then focuses on why annotations are so effective in education and the main types of annotations used in research. The second part of the chapter explores examples of the use of cues in experiments that use annotations to specifically direct novices' gazes.

2.3.1 Definition, theories and effectiveness of annotations

There are very few definitions of what annotations are. However, in the current work, they are considered the results of processes in which individuals analyse and interact with different objects, such as documents or images (Stefanut & Gorgan, 2008). By contrast, Zywica and Gomez (2008) considered annotations to be a 'reading strategy' for learning because annotations help in structuring and marking a text. Examples include highlighting or drawing marks around important parts of a text, such as definitions, key content, or words.

The importance of annotations as an instructional method in multimedia learning is explained by different cognitive models that trace back to the beginning of cognitive psychology. The effectiveness of annotations is based on how attention works and the limited capacity that the human brain has to process information in the visual field. This idea dates back to the 1800s when James (1890) proposed a model of attention consisting of a focalisation and concentration process. Many years later, this model evolved into the zoom lens model (Eriksen & Hoffman, 1972) and the spotlight metaphor (Posner, 1980), which argue that attention can only be given to a certain section of the visual field, those sections are where the information receives the highest level of processing, while the rest of the visual information remains on the visual periphery and receives limited attention.

These theories were developed in the areas of education, instructional design, and multimedia learning. For instance, the cognitive load theory, developed by Sweller (1988), indicates that instructional methods must consider the limits of human working memory and avoid the overload of information by using aids to help the learner's memory. A way to do this is to avoid overlapping information coming from the same channel (picture and text) and to rather use instructions organised in two different channels. Another aid to improve memory and understanding is the presence of previous training, as the learner's experience can serve as a scaffold to support the learner.

From cognitive load theory, another ground-breaking theory laid the basis for instructional design and multimedia learning: the cognitive theory of multimedia learning (Mayer, 2005). This theory says that humans' ability to process pictures and words in working and long-term memory depends on the words' modality (i.e., written or spoken). For learning to occur, relevant information from the material must be visually selected, organised in mental models, and integrated with prior knowledge. Furthermore, Mayer developed the following principles to create effective visual material:

1. Coherence principle: People learn better when extraneous words, pictures, and sounds are excluded rather than included.
2. Signalling principle: People learn better when cues that increase the saliency of essential parts of the material are added to the material.
3. Redundancy principle: People learn better from a combination of graphics and narration rather than from graphics, narration, or on-screen text alone.
4. Spatial contiguity principle: People learn better when corresponding words and pictures are presented close together rather than far apart from each other on the page or screen.
5. Temporal contiguity principle: People learn better when corresponding words and pictures are presented simultaneously rather than successively.

6. Segmenting principle: Principle: People learn better from a multimedia lesson if it is presented in user-paced segments rather than in continuous units.
7. Pretraining principle: People learn better from multimedia lessons when they know the names and characteristics of the main concepts.
8. Modality principle: People learn better from graphics and narrations than from animation and on-screen text.
9. Multimedia principle: People learn better from words and pictures together than from words alone.
10. Personalisation principle: People learn better from multimedia lessons when language is used in a conversational style rather than a formal style.
11. Voice principle: People learn better when the narration in multimedia lessons is spoken in a friendly human voice rather than a machine voice.
12. Image principle: People do not necessarily learn better from a multimedia lesson when the speaker's image is added to the screen.

For the present work, the most relevant principle is the *signalling principle,* which postulates that extraneous material can draw the attention of learners and cause them to engage in cognitive processes that do not support the learning goal. To avoid this issue, cues can be implemented to direct learners' gaze and consequentially their attention towards the highly salient sections of the images. This direction can be performed with different types of annotations, such as text, highlights, colours and others. The important feature of the cues is that they do not add anything new to the content of the material but that they help with mental organisation. The effect of the signalling principle has been well tested in research and found to result in a lower cognitive load, more focused attention and better comprehension and retention of content compared to non-signalled conditions (Corkill, 1992; De Koning et al., 2007; Dodd & Antonenko, 2012; Richter et al., 2016; Spyridakis et al., 1989).

2.3.2 Types of annotations and their use in education research

There are many types of annotations or cues which can be used in visual material that have been explored by researchers. According to Schneider et al. (2018), annotations can be divided into two major categories. The first category consists of cues applied to pictures: 1) organisational signals (e.g., headings or summaries); 2) colours (e.g., font colours); 3) text picture references (e.g., 'see the picture'); 4) intonation (e.g., nonauditory texts) and 5) a mixture of types (e.g., colouring and text picture referencing). The second category consists of annotations applied to text: 1) colours (e.g., parts of a picture); 2) labels (e.g., naming parts of an animation); 3) flashing or spotlights (e.g., greying out parts of an illustration); 4) graphic organisers or, again, a mixture of two before and 5) other types (e.g., pointing gestures and labels).

These different types of annotations have been used in education research for decades and have achieved consistently positive results with respect to the learning process. For instance, *coloured indicators* have proven useful for participants with low spatial skills in solving mental rotation tasks (Roach et al., 2019). Moreover, the use of colours with translucent colour patches applied to golfing training videos can help novices acquire golfing movements more quickly (D'Innocenzo et al., 2016).

Other types of annotations that are widely used are *diagrammatic elements* such as lines, blobs, boxes, crosses, arrows and circles that help one understand complex representations (Heiser & Tversky, 2006), such as technical drawings or biological illustrations (Azkue, 2013). For example, arrows applied to an animation displaying the functioning of a piano have been shown to increase attention towards relevant sections, resulting in a better comprehension of the movements of piano keys (Boucheix & Lowe, 2010).

2.3.3 Guiding attention to improve gaze interpretation

There are two main approaches used in attention-guiding: the first approach is to use annotations created by experts and are displayed on top of the visual material that students have to observe, while the second approach is to create cues based on the real eye movements of the experts and display them to the apprentices. In the first case, the use of lines or arrows have proven useful. For instance, arrows applied to an animation displaying the movement of a piano increased the attention of the student towards relevant sections, resulting in a better comprehension of the movements of piano keys (Boucheix & Lowe, 2010). In other experiments, circles and colours were used to improve the diagnostic performance and visual processing of novice radiologists; the participants were shown radiographies with highlighted visual characteristics, such as yellow circles, shading on irrelevant areas and the use of colours to highlight the lines of the fractures. The results indicate that the diagnostic performance of the novice radiologists increased (Scheiter et al., 2019).

In the second case, the assumption is that experts (e.g., radiologists) observe the most important areas (e.g., lesion) of the image (e.g., X-ray) and that it is possible to group the eye movements of the experts and display them to novices on top of the visual material (an approach called modelling). In this manner, learners are exposed to an expert's gaze pattern under the hypothesis that they will implicitly learn where to look and, hopefully, replicate the pattern in other materials. For instance, in one study, researchers asked participants to view videos showing a fish with a specific type of locomotion and listen to an audio description. The video in the experimental condition contained annotations based on the eye movements of an expert marine zoologist. The experimental group spent less time on the stimuli before examining the cued sections and spent more time - in terms of milliseconds - on the relevant portions (see Jarodzka et al., 2010; Jarodzka et al., 2013).

Sharma et al. (2015) superimposed a teacher's gaze in an educational video to help students to have a better understanding of the teacher's gestures and be more engaged. Similarly, Mason et al. (2013) used a model's eyes (expert eye movements) in an experiment on graphic and text processing by showing participants the model's eye in the form of red dots. They showed that learners spent more time fixating on the relevant parts of the visualisation while reading the text and that they also had better recollection on the post-tests than the participants in the control group.

2.4 Annotation tools for visual expertise and the platform Realto

This section identifies examples of current tools that are available to the public and have annotation functions and tools specifically developed for some professions. The section will also present the platform Realto and its annotation tool, which was used in Study 3.

There are many applications that contain annotating functions that are already available in the devices people use in their daily lives. For instance, any smartphone has built-in annotating functions, such as the default 'Photo' application present on the iPhone. Moreover, chat and messaging applications often contain these functions too, such as WhatsApp, which allows one to manipulate received and stored content. Therefore, annotation is already easily available to anyone who wants to use it. Similarly, annotations can be added directly in simpler software, such as SketchBook Pro, and more complicated software, such as Adobe Photoshop or Illustrator. Annotations are also available in the main text-processing software, such as Microsoft Word, and have been integrated into the editing functions such as the ones of the Adobe software's.

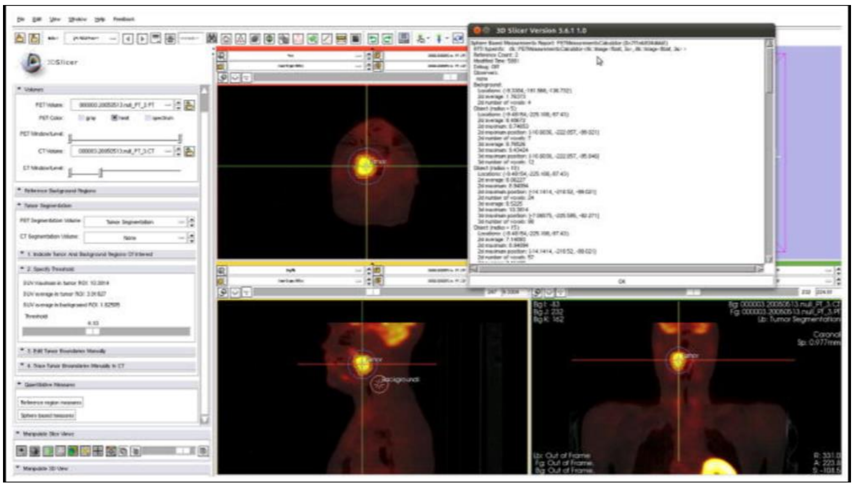
Annotations are fundamental in many professions, but this need is most evident among medical professions, which have invested time and resources to build tools to facilitate their work. These tools allow for the annotation of 2D and 3D (or volumetric) images. The following are some examples of applications and software:

– *LesionMap* (Eapen et al., 2020) is a comprehensive tool that contains functions to apply textual annotations to the images of skin anomalies. These textual annotations contain information about the orientation, width, position and opacity of the anomaly.

– The *dermoscopy tool* contains manual segmentation, labelling and image-manipulation functions (Ferreira et al., 2012).

– *Visual Interpretation with Three-Dimensional Annotations* (VITA - Roy, Brown and Shih, 2014) automatically generates 3D rotating visualisations and allows for the annotation and reporting of radiology.

– *3D Slicer* is a multiplatform free and open-source software for the visualisation and computation of medical images. The tool includes a rich set of annotations to support quantitative image analysis (Fig. 2).



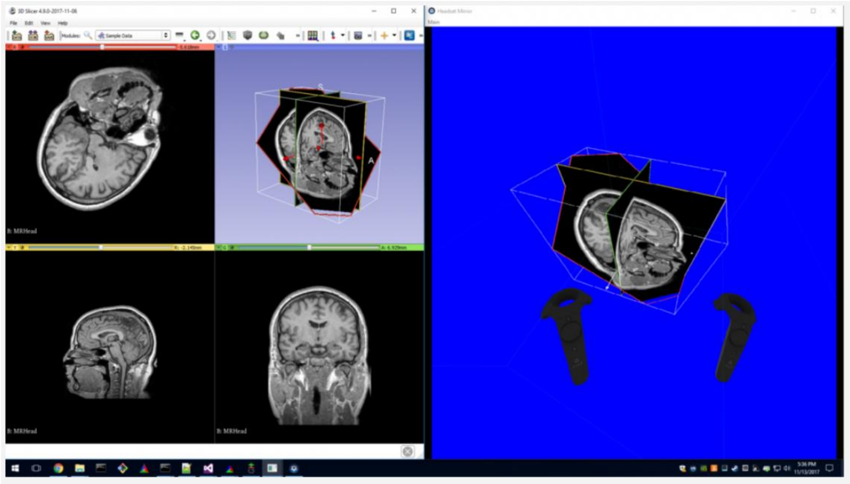


Fig. 2 – 3D Slicer

– *WebMedSA* (Vega et al., 2015) is used in teleradiology to manage large datasets of medical images; it supports the annotation, segmentation and visualisation of images based on their semantic description (Fig. 3).

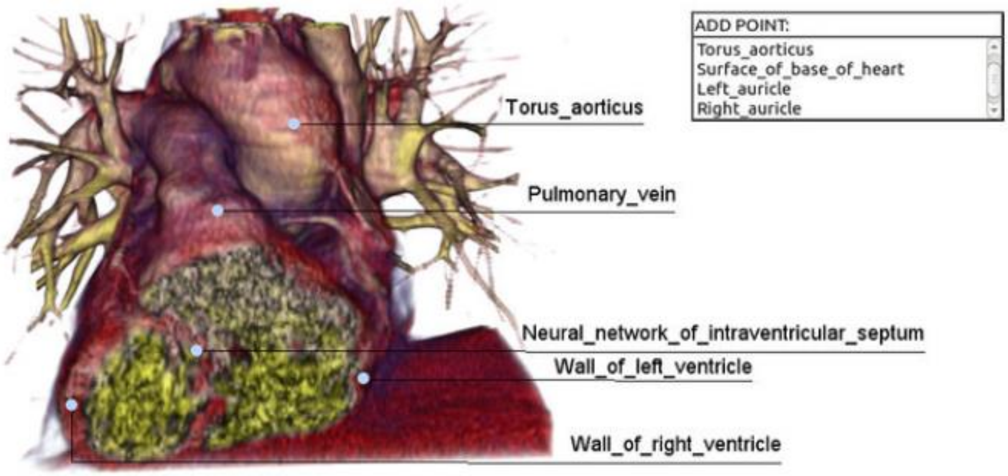


Fig. 3 – WebMedSA (Vega et al., 2015)

– *Anatoma* (Azkue, 2013) is a visualisation and annotation tool developed to create annotations on body anatomy. The tool is composed of a database of anatomical structures that are presented in full resolution with a series of functions for visualising, manipulating (e.g., rotation, zoom, translation and lights) and annotating (e.g., writing names and notes, dragging info, adding numbers, using colours to distinguish parts of the body, using markers and text input) images (Fig. 4).

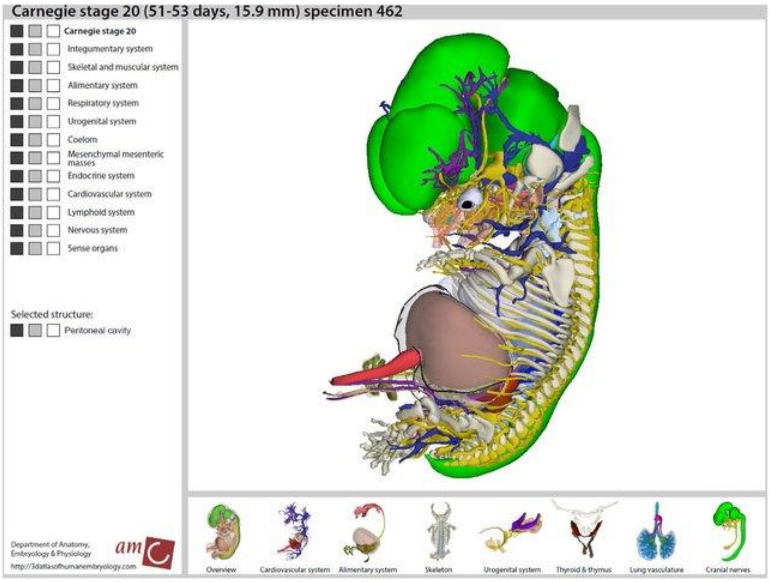


Fig. 4 – Anatoma (Azkue, 2013)

– *eTRace* (Stefanut & Gorgan, 2008) is an annotation tool for students to grab, select, position, sketch, write and deform a 3D image. The application can be used by teachers to create lessons in the application by using video, sounds and images (Fig. 5).

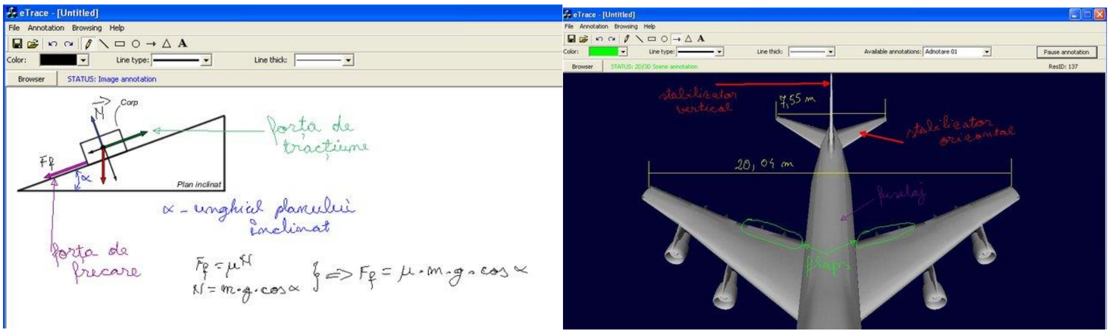


Fig. 5 – eTRace (Stefanut & Gorgan, 2008)

- *ZaWin32* (MartiSoft) is an application for dental assistants and dentists that uses different kinds of functionalities to replicate the status of the mouth of the patient. Teeth can be removed, coloured and reshaped, and cavities and current implants can be marked using the table on the top of the image (Fig. 6).

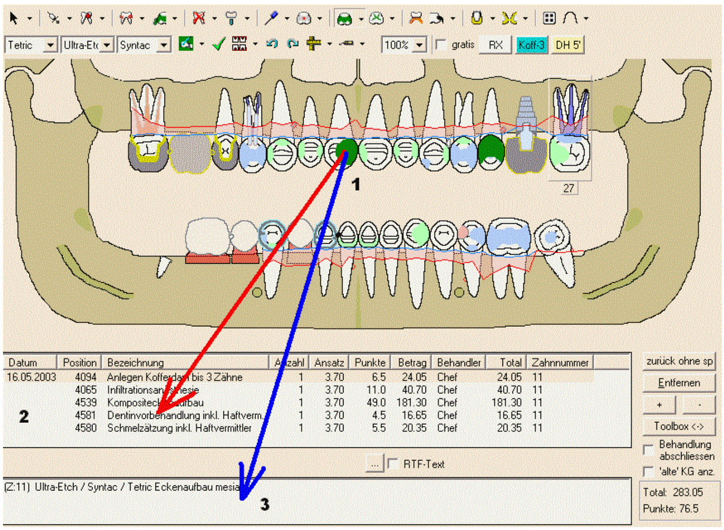


Fig. 6 – Dental representation in ZaWin32 used by some dental assistants and dentists in Switzerland

All the applications presented above have been created mainly for the medical field and have specific uses in practice. The platform Realto is presented below, which contains an annotation tool that is not as complex as the applications mentioned above, but the platform contains other functions that have been used in Study 3 that were successful in helping students increase their visual expertise.

The tools presented above have different levels of complexity and a variety of functions. In this work, the tool used in the third study for the apprentice's annotations involved the platform Realto. The platform is a learning environment developed within the Dual-T project and offers apprentices, teachers and supervisors a variety of functions to work on professional content. Realto offers a closed social-network-like structure that allows teachers to create groups for each of their classes where apprentices can share the content related to their work experience in the form of posts displayed in a timeline format similar to Facebook (Fig. 7).

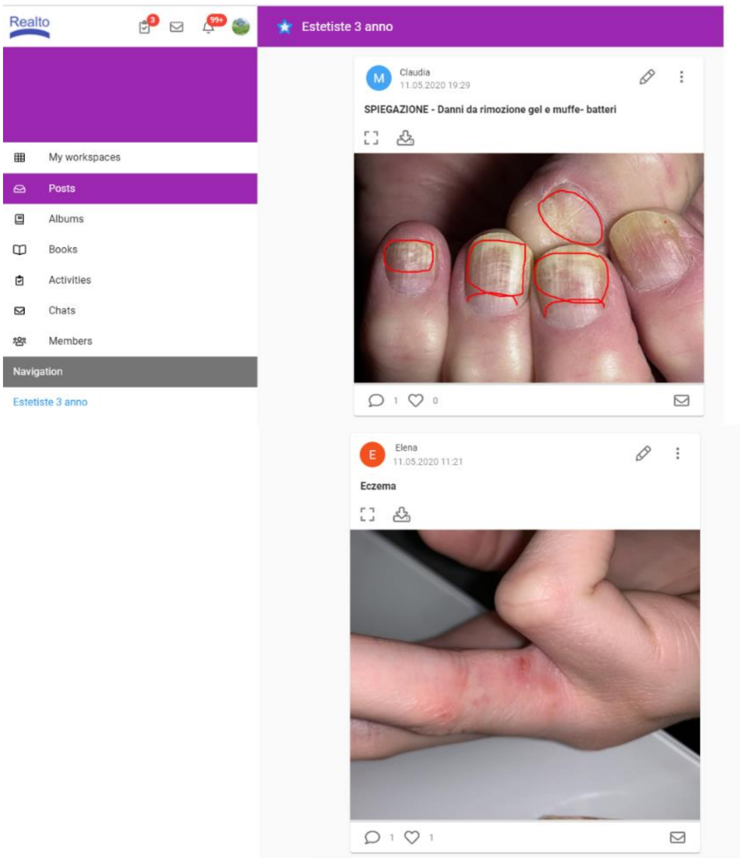


Fig. 7 – Realto's workspace and timeline (teacher view)

Furthermore, teachers can create a wide range of activities for their class, such as image annotation activities, text activities, an activity journal called *learning documentation*, multiple-answer questions or checklists. When creating an activity, teachers must generate a post and then they must specify the type of activity desired and add all the necessary content, such as images or files, and finally, they must specify a deadline and initiate the activity. Moreover, activities can be stored and activated later and can be reused with other classes on the platform. When an activity is live, the users will be able to distinguish it from a post via a blue bar. To complete the activity, users have to click on the blue bar that will redirect to the student's view (Fig. 8).

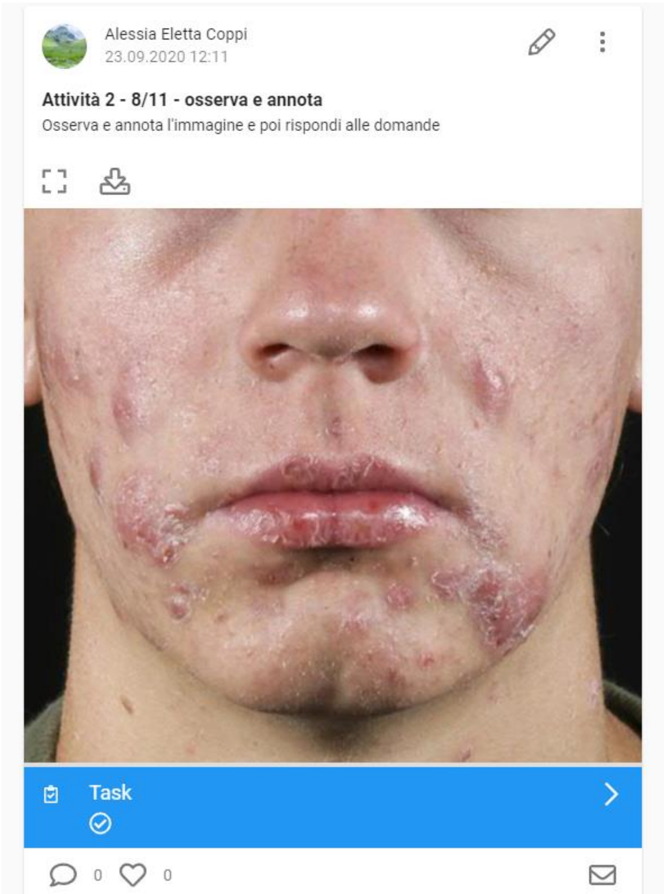


Fig. 8 – Example of activity in Realto (student view). Here the teacher asked the apprentice to observe, annotate the image and then reply to the attached questions

The first main function of Realto used in the present dissertation is the annotation function. This function can be accessed by all the users by clicking on any image they see in the workspace. Apprentices can annotate their own or classmates' images, and teachers can create image annotation activities. Annotations are performed using the annotation tool by clicking on an image and then pressing the 'Brush icon' (Fig. 8) that is visible on the top-right corner of the screen. Then Realto will display the picture on a black screen alongside the annotation tool bar. The annotation tool bar (Fig. 9) contains all the typical functions available in other annotation applications (e.g., SketchBook Pro). Users can perform different actions with the tool, such as (a) draw free lines; (b) add shapes (square, arrows and circles); (c) change the colours of shapes, lines and text; (d) select lines, shape or text; (e) add text and change its size and (f) edit the transparency and overlapping of the elements. The annotation tool is also available in the form of an activity called an 'image annotation activity'.

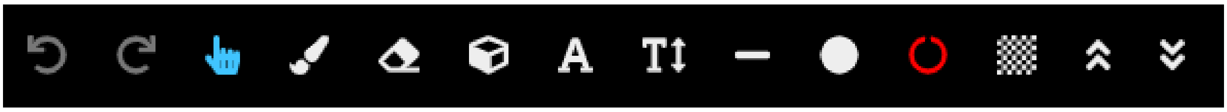


Fig. 9 - Buttons available in the annotation tool

Any annotation activity can be completed by or combined with other activities such as written activities. The apprentice can complete the activities by clicking on them (on the blue bar) and automatically accessing the student view (Fig. 10), where they can see the instructions and the content (e.g., images, files or videos).

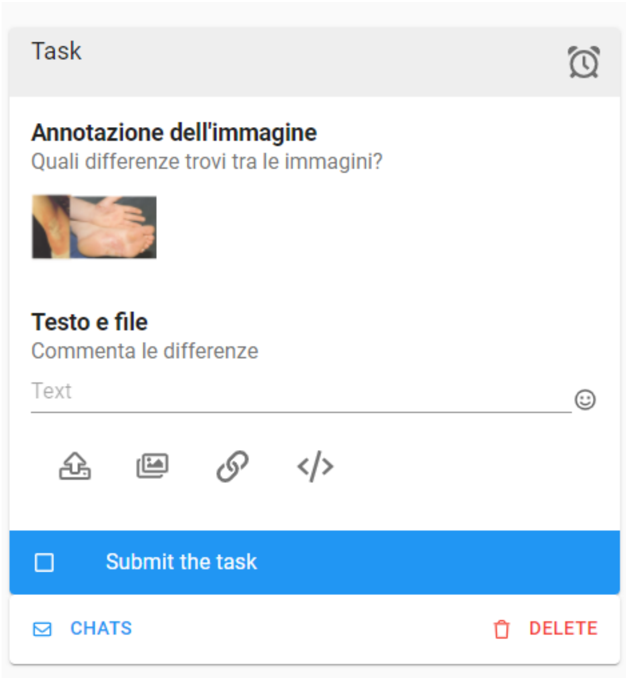


Fig. 10 - Student's view of a text activity

3. Research Aims

The present doctoral thesis is part of the framework of the Dual-T project, which is led by the Leading House ‘Technologies for Vocational Education and Training’ created in 2006. The Leading House is a cooperation between the Swiss Federal Institute of Technology in Lausanne (EPFL), the University of Fribourg (UNIFR) and the Swiss Federal University for Vocational Education and Training (SFUVET). The current dissertation explores the potential of using annotations to foster visual expertise in apprentices. Three different studies were conducted to achieve this aim, and the studies used both quantitative and qualitative methodologies. The first study was developed to explore the visual languages of vocational professions that include visual representations (e.g., technical drawings) and annotations (e.g., free lines) to understand which professions rely on visual material and which professions could benefit from interventions in school aimed at developing the observation skills of their apprentices. Based on the results of the first research project, a second study was developed to investigate the potential of using annotations to direct fashion-designer apprentices’ gaze towards relevant parts of profession-specific visual material. The results of these studies were then elaborated in a third study that aimed to foster beautician apprentices’ observation skills of visual material. The research questions are as follows:

- *How are the visual languages of vocational professions different from each other? What kinds of visual representations and annotations are used and produced in their daily practice?*
- *Can annotations affect the way apprentices look at profession-specific images?*
- *Can annotations performed with an annotation tool in a didactic scenario promote visual expertise?*

4. Overview of the Empirical Papers

In the form of an extended summary, this chapter underlies the theoretical underpinnings and methodological approaches used in the three studies we conducted for the present thesis (subproject 10 of the general Dual-T project). Study 1 is an exploratory study on the kind of visual languages used in different vocational professions, focusing on the specific visual representations (e.g., drawings) and annotations (e.g., diagrammatic elements) used and produced by different professions. Study 2 takes in the results of the first study to identify if annotations can convey to newcomers a sense of how the professionals of a given profession should look at images. Finally, Study 3 picks up from where the second study left off and illustrates how it is possible to foster observation among apprentices and teach them how observation should be used in the profession, hereby using annotations and working with visual representations.

The following section comprises a condensed version of the three manuscripts where the full publications are presented in the Appendix.

4.1 Study 1

Coppi, A. E., Cattaneo, A., & Gurtner, J. L. (2019). Exploring visual languages across vocational professions. *International Journal for Research in Vocational Education and Training (IJRVET)*, *6*(1), 68–96.

Introduction

Exploring visual languages is a complex task because it entails discovering a communication system that includes both representations (Chang, 1986) and annotations (Calvani, 2011). Representations are depictions of information in image or textual form (Pei et al., 2011); annotations are the different kinds of marks left on images or texts to highlight the relevant parts of these representations (Schraw et al., 2013).

Despite extensive investigations of the types and uses of visual language in higher education, there are only a few examples of research on this topic in the professional area, and most of these studies are focused on white-collar professions. For example, Pei et al. (2011) discriminated among the different representations used and produced by engineers, distinguishing among sketches, drawings, models and prototypes. Again, Hartswood et al. (2002) reported on how radiographers work with mammograms (formalised drawings of the body) on which they apply medical information. Another example is from Styhre and Gluch (2009), who showed how architects use sketches, complex computer drawings and photographs in their work.

A similar situation of neglect is recorded for the concept of annotations, which very few studies have explored outside of the realm of education; one major study is by Hartswood et al. (2002), who pointed out that radiographers use different notes to report abnormalities in their screening sheet, such as abbreviations like 'BT' for breast tissue, '?' to signal uncertainty, 'Benign' for benign patches or 'X NRC' for no real changes. In engineering, the most used annotations are arrows and lines, which are useful to emphasise the structural organisation and functioning of machines (Azkue, 2013), while in design, the preferred ones are written notes and signs (Eckert et al., 2012). The lack of research in vocational education leaves us with many questions about visual languages in vocational professions. For this reason, the aim of the current research is to understand the shapes of the visual languages produced and used by different vocational professions. This will allow us to understand what the role of images for these professions is, what kind of links or disparities are present within the current vocational training and, at last, what kinds of educational activities or interventions (also technological oriented) could be implemented to allow students to achieve the profession-specific skills that will be necessary when they will become professionals.

Methods

Data were collected in Switzerland through semi-structured interviews with full professionals (N=55) working in 11 different professions from the areas of craftsmanship, industry, health and services. The interviewees were asked questions about their use and production of representations and annotations, as well as to provide visual example of these materials. The interviews were then audio-recorded and manually transcribed using a coding scheme informed by the literature (see Pei et al., 2011); later they were analysed using the NVivo software.

Results

In terms of visual representations, the analysis showed that across professions, different types of drawings are used, such as technical drawings depicting machines, furniture or land (woodworkers); evaluation forms (dental assistants, massage therapists) to show the prototypical drawings of the parts of the body (e.g., denture); illustrations such as scientific illustrations of the body (massage therapists) or plants (winemakers).

The participants also indicated the practice of creating sketches depicting objects to produce or currently under development (goldsmiths, fashion designers) and full-coloured renderings of the final product or system (gardeners, multimedia technicians, woodworkers). The participants also gave photographs portraying things to remember, pay attention to (plumbers) or as reference pictures (gardeners, goldsmiths, fashion designers).

The participants across professions used annotations such as notes to specify task details such as measurements, schedules or materials to use (multimedia technicians); they also reported using profession-specific annotations, such as mathematical symbols (woodworkers, polymechanics, plumbers, multimedia technicians) and diagrammatic elements like lines and arrows (fashion designers) or crosses, letters like ‘X’ and hashtags (massage therapists). All in all, we can consider the language used as partially shared across professions: in fact, the participants sometimes shared similar representations and annotations across professions, but at other times, they used very specific visual languages.

Conclusion

The current study allowed us to uncover the various uses of visual language in multiple professions. Specifically, the results pointed to the strong presence of visual representations in a variety of different professions, also indicating that annotations are fundamental (e.g., in the case of the massage therapists and fashion designers) and widely used. The strong presence of a wide range of visual representations and annotations also testifies to the importance of visual skills across professions; indeed, professionals in various domains produce and use materials that require the observation of complex objects and real environments. How to exploit the potential of visual stimuli to foster these skills still requires investigation. If further research is needed to explore the value of technology-supported tools to foster students’ visual abilities with the help of representations and annotations integrated in instructional scenarios, our results should already contribute to design courses and activities more in line with real work practices.

4.2 Study 2

Coppi, A. E., Oertel, C., & Cattaneo, A. (2021). Effects of Experts’ Annotations on Fashion Designers Apprentices’ Gaze Patterns and Verbalisations. *Vocations and Learning, 14*(3), 511-531.

Introduction

The professional world is constantly evolving, and schools must prepare apprentices for an ever-changing, specialised and technological-driven world. Many higher education courses, mainly in the medical field, have addressed this necessity and have created curricula to train specific skills that are fundamental for the profession. For instance, in the area of radiology, there are courses dedicated to the development of the visual expertise of professional images (e.g., X-rays). Also, research itself has invested in exploring observational skills, where researchers are engaged in understanding the differences between experts and nonexperts; for example, studies have pointed out that novice doctors need more time observing images than experts (Krupinski et al., 2006), tend to look less at relevant areas of the image (Jaarsma et al., 2014), need more top exploration but have less content evaluation (Alzubaidi et al., 2009) and process information using bottom-up instead of top-down strategies (Morita et al., 2008). Identifying the ways to improve novices' visual expertise usually focuses on redirecting novices' attention, for example, exploiting Mayer's (2005) signalling principles according to which people learn better when essential material is highlighted. This can be done by introducing various cues (e.g., lines) or superimposing experts' gaze patterns on visual representations shown to novices (Sharma et al., 2015).

In the former case, cues have been found to benefit novices in the case of both static and dynamic images. For instance, Boucheix and Lowe (2010) added cues to an animation and noticed that students looked at the signalled points of the images where the annotation were placed and, at the end of the experiment, were better able to recall and comprehended the content of the animation. In the latter case, displaying experts' eye movements to the learners was revealed to increase students' engagement and decoding ambiguity (Sharma et al., 2015). Although the combination of the two approaches should be preferable, Jarodzka et al. (2017) indicated that future research on observational skills will benefit from performing experiments in a realistic environment, using methodological triangulation and using tasks that are essential to the professional domain. To fill this gap, the current study aims to investigate the observational skills in the profession of fashion designers to understand if annotations can convey a professional way to look at garments. Our hypothesis is that being exposed to a series of annotated professional images compared with exposure to nonannotated professional images will produce the following: 1) learners' gaze patterns will become more similar to experts', and 2) learners' verbal descriptions of the pictures will be closer to experts' in terms of richness.

Methods

Study 2 was conducted within the profession of fashion designers; the sample was composed of an experimental group (n=20, all females) and a control group (n=17, all females), both enrolled in the second year of their course.

In a *pre-test phase*, all the participants were exposed to a set of five images depicting garments displayed on a PC. Each picture was displayed for 40 seconds, during which the participant was asked to verbally describe the depicted garment. For the *training phase*, the participants were randomly assigned to the experimental or control condition. In the former condition, they were presented with a series of five images (40 seconds each) with visual annotations (e.g., circles) and audio description. Then, five other images, annotated by the teacher, were presented (40 seconds each), with a request for the participants to provide their verbal description of the picture. In the latter condition, the participants were shown the same images with no visual annotations, and the participants were first shown five images with an audio description only and then a set of five images that they had to verbally describe. In the *post-test phase,* both groups were asked to observe five images (40 seconds each) and orally describe them, as in the pre-test phase. Tobii Pro Studio software and a Tobii Pro X2-60 eye tracker unit were used to record the participants' gaze patterns.

Measure and materials

Quantitative data were formalised into the variables of fixation durations and gaze coverage, while the qualitative data were formalised into the variable of verbalisation score. A full description for each of the measures and the extensive process of cleaning and creation of the areas of interest are presented in full in Appendix.

Results

For *fixation durations* (*amount of time the eye remains still over a period in one location),* a series of general linear mixed effects models (GLMMs) were carried out with the fixation durations extracted for each of the areas of interest (AOI – *sections of the images relevant for the research and from where the gaze data are extracted)* created for training 1 and training 2 ('Central', 'Neck', 'Sleeve' and 'Shirt') and for the pre- and post-tests ('Central', 'Neck', 'Sleeve' and 'Details'). The results for training 1 indicated that the experimental group looked longer at the AOIs 'Central', 'Neck' and 'Sleeve', but no significant difference between the groups was found for the AOI 'Shirt' (while the AOI 'Details' was not present). Conversely, in training 2 the experimental group fixated significantly less than control in the AOI 'Shirt' and no difference was found in other AOIs beside 'Sleeve' where the control group looked longer. Further, results of the pre and post-test pointed out that the experimental group looked significantly longer in the AOI 'Central' than control. However, the other AOIs showed no significant difference between the groups.

For *gaze coverage (the proportion of the image gazed at by the individual at least once)*, a series of GLMMs were carried out. A GLMM was conducted to compare the effect of the presence of annotations on gaze coverage. The results showed that the interaction between condition and gaze coverage is just not significant *[F(1, 236.091) = 3.747, p =.05]*. Planned post hoc comparisons indicated a significant difference *[F(1, 48.289) = 4.510, p <.05, d=.451]* between the experimental and control groups at the post-test. The mean values indicated that in the post-test, the experimental group covered a larger portion of the image compared with the control group (*M_{exp} = 10.95, SD = 0.287 vs. M_{con} = 10.82, SD = 0.289, respectively).*

For *verbalisation (amount of correct details in the shirt mentioned by the participants)*, a repeated measure ANOVA was conducted to compare the effects of the condition on the verbalisation score (number of enunciated details) in both the pre-test and post-test. A main effect of the verbalisation score $[F(1, 35) = 7.681, p <.01, \eta_G^2 =.769]$ was identified, but the between-subject effect was not significant.

Conclusion

The results indicated that our hypothesis can be confirmed in the AOIs ‘Central’, ‘Neck’ and ‘Sleeve’ of training 1, ‘Shirt’ of training 2 and the AOI ‘Central’ of the post-test. However, these results indicate that the impact of annotations was limited to when present on screen in the training session and that, in their absence, the experimental group looked longer than control only in one AOIs at post-test. Also, if training 1 seems to have affected the apprentices’ gaze as expected that was not true for training 2 where, beside ‘Shirt’, no difference was found in the AOIs for the experimental group. This partially unexpected result might be traceable to the modality effect (Glenberg et al., 1989). This effect indicate that cueing performed with both visual and audio is more effective than cueing that uses only one of the two channels (see Mayer, 2002).

At the same time, we expected that at post-test, the experimental group would have achieved a larger gaze coverage of the image because annotations were placed in all the most relevant parts of the shirts to train apprentices to observe certain areas, but also to force apprentices to observe the garment in its totality. However, only a merely statistically significant difference was found between the two groups, even if the experimental group covered a larger portion of the image at post-test compared with the control group. This result is not completely out of the ordinary because fostering coverage of images can be a complex task, and sometimes, after interventions, the increased coverage can be limited (see Eder et al., 2021).

4.3 Study 3

Coppi, A. E., & Cattaneo, A. (2021). Fostering Apprentice Beauticians' Visual Expertise Through Annotations: A Design Experiment Using the Platform Realto. *Journal of Education and Training Studies*, 9(7), 27-40.

Introduction

Beauticians must learn how to perform skin analyses to recognise most skin diseases and provide correct treatment. Apprentices also need to know how to differentiate medical anomalies (e.g., psoriasis) from mild anomalies (e.g., dry skin) to avoid causing damage and, instead, refer clients to a dermatologist. However, beauticians have roughly one semester for learning these topics, while dermatologists have years and specific training methods; one example is the successful perceptual and adaptive learning modules (PALMs) (Rimoin et al., 2015) that rely on a flashcards method to expose novices to anomaly images and their names.

A possible way to increase observation in apprentices would be to combine the elements of current training for dermatologists and use methodologies generally used for observational training. Among these, the use of annotations (e.g., arrows, circles) has been shown to be beneficial in leading novices to observe desired sections of images and develop a deeper understanding of what they see (Boucheix et al., 2013). As well, the use of (written or verbal) descriptions proved to be effective in verifying novices' expertise in observing professional images (e.g., Jarodzka et al., 2010).

Based on this, this study aimed at understanding if annotations and descriptions could foster observation with the hypothesis that the students exposed to an annotation- and description-enriched training (on a web-based learning environment called Realto) will 1) write more detailed descriptions compared with the control group, 2) perceive annotations and descriptions as having a positive impact on observation and 3) rate the experience with Realto as positive.

Methods

Materials

The materials used in the experiment were the following: 1) a (*pre–post*) *test* developed by the teachers and containing 11 images of skin anomalies to observe and annotate; 2) a *questionnaire* focused on exploring apprentices' experience with annotations and descriptions; and 3) a *discussion guide* to investigate observation in the profession through a focus group and the experiences with Realto.

Participants

The experimental group was composed of a second-year class of nine apprentices (M_{age}=17, SD_{age}=0.75, all females). A second class of 19 students (M_{age}=29.6, SD_{age}=9.83, all females) at the beginning of their third year of training was also involved to provide a baseline for comparison. Apprentices were recruited from one of the vocational schools in Switzerland, which provides a well-established vocational beautician curriculum.

Procedure

In January 2020, all apprentices were asked to observe 11 images of skin anomalies and provide a written description of them (pre-test).

In the training phase (February to June 2020), the experimental group was exposed to training sessions run with Realto and organised as follows: 1) the teachers presented the participants pictures of skin anomalies uploaded in Realto, annotated them (e.g., with circles) and explained how to recognise them from similar ones; 2) the students received a second set of images in Realto (without annotations) and were asked to annotate them and write a description per each image; and finally, 3) the teachers showed the participants the annotations of all their classmates and they corrected them with the students. In June 2020, the students were asked again to observe 11 images of skin anomalies and provide a written description of each of them (post-test). The same test was also presented to another class, which just finished treating the topic of skin anomalies (and was then in the beginning of their third year) and which served as a kind of baseline group. The participants of the experimental group, but not of the baseline group, were also asked to fill out a questionnaire about the experiment and how they view the importance, usefulness and value of annotations. Also, the two teachers and three students were asked to participate in a focus group on the topic of observation, use of annotations and Realto.

Results

For the analyses on the *written descriptions*, a Wilcoxon signed-ranks test was run on the pre-test and post-test written descriptions scores of the experimental group. The post-test ranks (Mdn = 28.00, SD =3.23) were higher than the pre-test (Mdn = 14.00), (Z = 2.371, p =.018, η^2 =.80), confirming the direct impact of the activities on the number of details present in the descriptions. Further, a Mann–Whitney U test was run with the post-test (which was the only one for the baseline group) scores of the experimental and baseline groups. The results indicated that the experimental group wrote at post-test (Mdn = 28.00, SD = 6.14) significantly more details compared with the baseline group (Mdn = 16.00) (U = 6.50, p =.001, η^2 =.47), suggesting a positive impact of the treatment.

Analyses on the *questionnaire* suggested that the apprentices considered annotations and annotation tasks as important and useful. The exercises helped them observe anomalies by highlighting the textures, dyschromias and peculiarities of the anomalies. Moreover, the descriptions were also considered helpful because they made them think more deeply about the anomalies' features and differences.

Further, the results of the *focus group* highlighted the different strategies of observation used by teachers and apprentices; they pointed out that annotating images was useful, but it was also important to see the correction performed by the teacher and their classmates' annotations and written replies. They expressed a desire to continue using Realto and its annotation tool to train observation and other tasks.

Conclusions

Despite the limited sample and lack of a real control group, the results indicated that annotations and descriptions can foster observation and that both the apprentices and teachers perceived the training as having a positive impact on observation. This shows 1) that this kind of training method could be part of beauticians' curriculum and 2) that Realto is valuable for training young professionals, as already attested in other studies (see Caruso et al., 2017).

5. Discussion

The main aim of the current dissertation is to foster visual expertise in apprentices using annotations. To achieve this goal, three studies were conducted to 1) explore the visual language in the professions, 2) identify the effectiveness of using annotations to train apprentices' visual expertise in an experimental setting and 3) foster observation in a didactic scenario using annotation technologies. The following chapter contains a discussion of the obtained results structured in relation to the research questions and a reflection of the potential impact of this dissertation in vocational education.

The first question is as follows: *How are the visual languages of vocational professions different from each other? What kinds of visual representations and annotations are used and produced in their daily practice?*

The answers to this question mainly come from the first study. The findings displayed the complexity of professionals' visual language and indicated that workers produce a wide range of visual representations—such as drawings, sketches or photos—and that, simultaneously, they use and produce a wide range of annotations in the form of diagrammatic elements, symbols or notes. Moreover, this extensive visual language can be shared with professionals in related fields (e.g., polymechanics and woodworkers) or can be unique to that profession (e.g., fashion designers).

These findings illustrate the unexplored potential of working with professionals' visual language in both general research and in vocational education. For research in general, the relevance of the current study is that it is one of the first—if not the first—to investigate this topic in vocational education, and not in a more well-known area such as engineering. More studies on this topic in VET could produce better alignment between vocational education and real professions by integrating the daily experience of workers with the school curriculum. This gap between school and apprenticeship experience is a known concept in the field of Swiss VET (Cattaneo & Aprea, 2018), but research should strive to close it to allow apprentices to be as competitive as possible; a stronger link between the representations viewed at work and the ones studied in class could increase the visual expertise of apprentices. For instance, vocational professions heavily rely on visual expertise since their professionality is built upon their ability to read and reason with complex images and not only in their procedural knowledge (see Lehtinen et al., 2020). For instance, professionals like polymechanics can be confronted with a long list of hundreds of technical drawings that comprise all the sections of a specific piece, and they need to be able to understand, visually organise and explore this visual material; it is therefore essential that these skills have already been learned in class.

Notwithstanding the methodological limitations regarding the sample size, this first study allowed one to glimpse into the world of vocational professions, which have been overlooked in many areas of research in favour of white-collar professions and nonvocational education. Research on visual language has mainly examined engineering professions, thus ignoring related professions in the vocational field, such as woodworkers, plumbers or polymechanics. Moreover, the results of Study 1 highlighted the strong presence of visual representations in a variety of different professions and indicated that annotations are fundamental in professions such as massage therapy and fashion design. These results can lead to more specific research on visual language that could subsequently lead to better VET. For instance, this could lead to the introduction of curricula dedicated directly to learning the visual expertise necessary for a given profession and for the vocations the apprentices will have to collaborate with (e.g., gardeners and woodworkers).

The next questions can be answered by mainly the second study: *Can annotations affect the way apprentices look at profession-specific images?*

The findings of Study 2 highlighted the impact of annotations in attracting learners' attention (cueing), indicating that they are a valuable tool for teaching visual expertise. This is especially evident from the results of the fixation durations, which showed that, when annotations were presented on a screen, they were successful in directing the gaze of the apprentices to specific areas of the shirt (training 1 and training 2) but were less effective when absent (pre-test and post-test). This result is not unexpected, and it is in line with the literature on cueing and gaze, which has indicated that different annotations can influence where apprentices are looking in both static and moving images (see Boucheix & Lowe, 2010; D'Innocenzo et al., 2016), leading to apprentices more deeply comprehending the visual material. This is because of the presence of annotations, which reduced apprentices' cognitive load by augmenting the saliency of the most important areas of a given image (see Mayer, 2005), which led to the experimental group observing those areas longer. The results regarding gaze coverage suggest that annotations were also helpful in teaching apprentices to look at the images in their entirety, as professional fashion designers must do in actual practice to produce correct patterns from photos and garments.

Study 2 is important for fashion design because visual expertise is fundamental for the profession and the inclusion of annotation as a training method. This task is regularly performed in class since it is preparatory for the creation of a garment's pattern and is repeated until the novice can represent the garments including all its many details. This task is not simple since missing minor details (e.g., piping) in a drawing might produce a multitude of errors. However, even if apprentices are exposed to this task frequently and guided by annotations, the emphasis on visual learning is still very implicit and reliant upon the sensibility and natural disposition of the apprentice, which often leads to poor results in the class activities. The results of the study showed that using annotations can attract the apprentices' attention to the relevant part of an image and can be implemented in making observation central to the learning process with ad-hoc activities cantered on this topic.

Even considering the limitations related to sample size, design and the complexity of eye tracking, this experiment leaves many doors open for the exploration of gaze in VET and in the fashion design profession. For instance, exploring experts' and apprentices' observations patterns can help create studies for fostering apprentices' observation abilities. Moreover, it could be interesting to observe the real-time interactions between apprentices and garments. Such observations could allow one to better understand where apprentices are looking at while working on the actual garments or its visual representations (e.g., sketch) and if well-trained observation skills are correlated with high spatial skills while apprentices draw garments and a better understanding of the structure of the garment.

The third question can now be explored and reads as follows: *Can annotations performed with an annotation tool in a didactic scenario promote visual expertise?*

This question can be answered by Study 3, which continued the work of Study 2. The results highlight that the training affected the experimental group, which could record almost double the number of details present in the images compared to the baseline group. Furthermore, the questionnaire revealed that annotations were considered useful when they identified anomalies by highlighting textures, dyschromia and peculiarities. Both apprentices and teachers further reported a generally positive experience with the activities and the Realto platform. This work reiterated the potential of using annotations to foster visual expertise in vocational education not only in an experimental setting but also in didactic scenarios. Moreover, Study 3 showed the importance of developing visual expertise in vocational professions; beauticians must perform skin analyses in their everyday practice, but the curricula trains apprentices on the topic only for a short time compared with other professionals such as dermatologists, who spend years on skin anomalies; however, beauticians must provide treatment for non-medical anomalies and treat other conditions of the skin. It is indeed fundamental that apprentices be able to quickly identify anomalies to avoid damaging the skin, and the Realto platform helped apprentices achieve proficiency in identifying anomalies. The features of the annotation tool itself allowed apprentices to annotate images themselves following the instructions of teachers and after having seen their teachers' annotations. Furthermore, Realto allowed the apprentices to see their classmates' annotations at the end of the exercise and view corrections of the annotations. Moreover, the apprentices were asked to provide a written description of the images, and this was also important because the apprentices reported taking more time to observe the images following this request. The introduction of Realto also had an impact on the way the teachers presented the lesson material. Before the experiment, they were relying on PowerPoint, but following the experiment, they began presenting lessons directly on Realto, where they could enact methodologies of attention-guiding and then produce different activities on the lesson topic.

Returning to the third question, using Realto with the beauticians proved the potential of using the platform and its annotation tool for vocational education and in fostering visual expertise. With its image-related function coupled with image annotations, Realto can continue being at the centre of vocational education; possibly also together with its image-overlapping function, which has proven useful for fashion designers and/or with the learning documentation function available in the platform, which is a current requirement in all Swiss VET programmes (Caruso et al., 2020). Similarly, beauticians can continue to profit from this work in different ways. A new study could be developed to further understand how experts and novices observe images of anomalies. Other studies could focus on real clients' skin, as apprentices do at the final exam and in the workplace. This will eliminate the biases created by having apprentices observe only images and give them a full training experience that captures what it means to observe someone's skin for anomalies in addition to determining the best skin treatment.

Other vocational professions can profit from this project and Realto in a similar way to that of beauticians and fashion designers. For instance, technical professions can integrate Realto into their education and use image-manipulation functions to overlap technical drawings and annotate the relevant parts of images to guide apprentices' observations of complex drawings (State Secretariat for Education, Research and Innovation, 2018). Gardening apprentices can also use Realto to foster their ability to recognise plants and plant anomalies; in this field, apprentices have to memorise at least 300 types of plants in their course and 150 plant anomalies, and Realto, with its annotations and observation exercises, could be integrated into the curriculum. As another example, massage therapists could be trained to observe a patient's body in a more specific way and to identify anomalies (e.g., rotation of the pelvis, pronation, etc.) that the patient is not aware of, and that novice massage therapists might have difficulty recognising. There is a wide range of possibilities that are worth exploring with methods that include annotations and image descriptions.

6. Conclusion

This thesis has contributed to the literature concerning visual languages, the enhancement of visual expertise in apprentices using annotations and the potential of using annotation technologies for visual expertise.

The findings showed that the wide range of representations and annotations are integral for in the studied professions and the education of apprentices. The findings simultaneously confirmed that the gap between the school and the workplace is still present and that apprentices often enter the workplace unexperienced not only in required tasks but also in understanding important visual material. Other discoveries from this work confirmed the importance of visual expertise in the professions and the necessity of training apprentices more extensively regarding this skill. Professionals such as fashion designers and beauticians must carefully observe visual material to identify details, anomalies or features. However, schools sometimes train apprentices in this skill in an implicit way, which downplays the importance of this skill for the profession. Further, the second and third studies showed that annotations were a successful training method for visual expertise and that, in both an experimental design and in a didactic scenario with a class, they made apprentices able to observe the relevant part of the image and observe it more systematically. This result can be considered an initial step toward implementing different training methods in vocational education to close the gap between the school and the workplace.

The use of Realto in one of the studies showed the potential of using educational technologies for a range of different tasks in classes. The positive results of the study can impact the way beautician apprentices are trained since Realto allows a teacher to explore more image analysis in the class. This results and the flexibility of the platform indicate there is a lot of potential to use it and create new educational scenario in many other VET curricula.

This doctoral thesis concludes by reiterating the need for vocational education to focus on visual languages and the processes of acquiring visual expertise since this expertise enables apprentices to develop the visual practices of their profession and become full-fledged experts.

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Appendix

The following pages present the full papers of Study 1, Study 2 and Study 3 as published online in their respective journals.

Coppi, Alessia Eletta; Cattaneo, Alberto; Gurtner, Jean-Luc

Article

Exploring visual languages across vocational professions

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Exploring visual languages across vocational professions

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Abstract

Context: Discovering visual languages across professions is a complex task since it entails discovering a communication system composed of information in image or textual form called representations and also including various kinds of annotations such as notes. Such a task has been previously scarcely considered within research, and basically only investigating in white collar professions (e.g., doctors). This leaves us wondering about all the possible shapes of these vocational visual languages and the potential of using these images to foster learning. For this reason, the current research aims to investigate commonalities and differences of visual languages across vocational professions with the goal of using the outcomes to design educational activities for vocational education and training (VET).

Approach: 55 semi-structured interviews have been conducted within eleven professions from the areas of Craftsmanship, Industry, Health and Services such a plumber and fashion designers. The interviews were audio-recorded and analyzed with NVivo through a coding scheme which served as the main reference for the analysis.

Findings Results showed that, in terms of visual representations, professionals use different types of drawings such as technical drawings (e.g., woodworkers), evaluation forms (e.g., dental assistants) and illustrations (e.g., gardeners). For sketches, participants indicate the practice of creating sketches depicting objects to produce (e.g. goldsmiths). For photos, they portrayed things to remember or pay attention to (e.g., chemical technologists). Participants

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across professions use annotations such as notes to specify details of their job. On the other side, they also report profession-specific annotations such as mathematical symbols like the surface roughness (e.g., polymechanics) and diagrammatic elements like different type of lines to indicate the status of the bones and muscles (e.g., massage therapists) or where to cut textiles (e.g., fashion designers). In terms of communalities, participants within technical professions indicated a shared use of both representations and annotations. Conversely, other professions had very specific visual languages hardly shareable across professions.

Conclusion: These results helped in discovering the visual languages of different professions and this knowledge will be used to implement educational activities based on specific skills needed in different professions such as observation skills with the use of VET-specific educational technologies.

Keywords: Visual languages, visual representations, annotations, vocational professions, vocational education and training, VET

1 Introduction

For many decades the exploration of language has been a topic of research in many disciplines, such as philosophy and communication (e.g. Chomsky, 1962), psychology and education (e.g. Vygotsky, Whorf, & Wittgenstein, 1990) professions and organization (e.g., Loewenstein, 2014) or semiotics and anthropology (e.g., Goodwin, 2004). These areas of knowledge focused on the concept of language, the impact of language in cognitive development or the use of textual and spoken language in different workplaces. Differently, this research will focus more on the topic of language from a visual point of view; visual language is a communication system that uses visual elements (Cherry, 1957) such as visual representations (Chang, 1986) or graphical signs like dots, lines, and arrows and their spatial relationships (Calvani, 2011). Aiming to research the visual language of multiple professions can be seen as a cumbersome task and one way to narrow the goal of this study is to focus on visual representations and annotations. These two concepts comprise most of the visual language of different professions and have also been the object of many years of research in the area of learning and psychology (e.g., Gibson, 1950; Anderson, 1978; Smith, 1998; Ainsworth, 1999; Arcavi, 2003). This is due to their potential for fostering students' and workers' learning and productivity by decreasing cognitive overload and enhancing general understanding. Although the research on representations and annotations is extensive, the principal investigations' focus is mainly on: 1) producing taxonomies, identifying the cognitive and psychological benefits and main uses and 2) white-collar professions rather than vocational professions. What about blue-collar vocational professions? What types of visual representations, annotations and colors do they use? Are there features or elements of visual language used across professions; is there any evidence of a shared visual language within and between these professions? Answering these questions could be beneficial for education and especially for vocational education: especially in dual systems, understanding better the use of visualizations within the professional domains could help on one side to bridge the gap between the work-based and the school-based track, and on the other side to design learning activities based on visual representations and fully exploiting the potential of annotations.

2 Theoretical background

2.1 Visual Representations

Visual representations are an established concept in the literature insofar as they have been studied in many humanistic sciences, although it is sometimes difficult to find a comprehensive definition of this term. Perini (2005) defined them as external objects that function as symbols, such as written text or numerical formulas. Other definitions that originated in the area of technology-mediated learning refer to visual representation as 'visual display', and specify that visual representations are representations of information that can have the form of text and static or dynamic images (Schraw, McCrudden, & Robinson, 2013).

In general, there is no widely accepted definition of visual representation; some of the prominent conceptualizations have focused on distinguishing different types of representations, such as internal and external representations (see, Gilbert, 2010), descriptive and depictive representations (Schnotz and Bannert, 2003) dynamic and static representations (Höffler, Schmeck, & Opfermann, 2013) and multiple representations (Ainsworth, 2006).

Alongside these studies, others have focused on representations such as drawings and sketches. In design and engineering the emphasis has been on producing taxonomies to unify the language and increasing understanding within the profession. For instance, Pei, Campbell and Evans (2011) created an extensive taxonomy that included different types of visual representations such as sketches, drawings, models and prototypes, with many different subsets (Fig. 1).

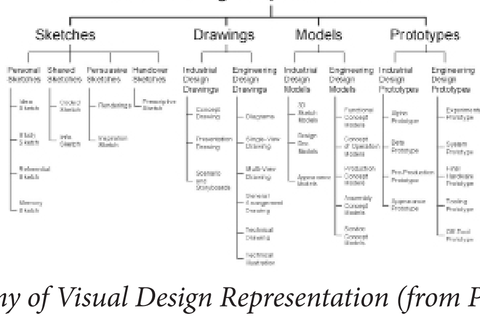


Fig. 1: Taxonomy of Visual Design Representation (from Pei et al., 2011, p. 7)

On the other hand, others distinguished between types of representation in design and engineering using the categories of: 1) concept design, 2) development design sketch, 3) embodied design and 4) detailed design (Kim, Jung, & Self, 2013).

Other studies have identified the types of representations used in different professions such as by architects, geographers, medical professionals, archeologists, manufacturers and dancers. In the case of architects, Styhre and Gluch (2009) indicated that they mainly use sketches, generate CAD images, retrieve photographs from the internet and use full-scale models. Geographers (Yates and Humphries, 1998) generate different types of schema such as a city map or others that are more suitable for showing relationships, such as a tube map. Radiographers (Hartswood, Procter, & Rouncefield, 2002) working with mammograms use capture sheets to report information such as the location of cysts, presence of pain, issues in reading the scans and diagnostic options (Fig. 2).

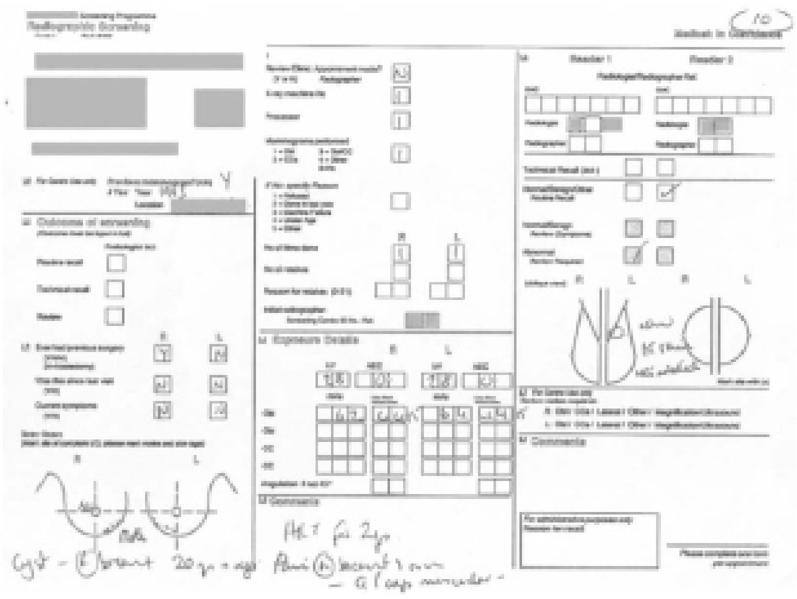


Fig. 2: Mammography screening report (from Hartswood et al., 2012, p.93)

In the area of design, some authors (Eckert, Blackwell, & Stacey, 2004) interviewed professionals and identified different categories of users of drawings; some use them extensively (e.g. designers or architects), others occasionally for a specific task (e.g. engineers or web designers), while others avoid using them (e.g. food designers). In other research on sketches (Stacey, Eckert, & McFadzea, 1999) the focus was more on the communicative aspects of sketches that can result in ambiguity and miscommunication due to their incomplete nature.

Furthermore, the same groups of researchers (Eckert, Blackwell, & Stacey, 2012) investigated the impact of computer-generated sketches on dancers' creativity; they asked dancers to interact with Choreographic Language Agent (CLA) software (Fig. 3), which produces random sketches from moving geometric shapes, and then use the outputs to create new combinations of movements.

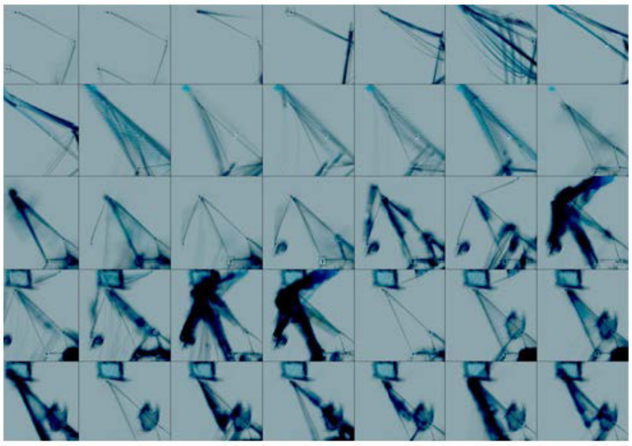


Fig. 3: Sketch produced by CLA software (from Eckert et al., 2012, p.7)

Finally, a famous example of research in this area is from Goodwin (see, 2004) that explored the concept of professional vision in different professions by analyzing graphic representations, highlights or coding schemes. Goodwin pointed out that professions such as archeologists use specific maps and charts (e.g. Munsel Colour chart) to understand the layering of the ground at excavation sites and that images allow them to categorise the world into coherent object that guide their perception in a professional way.

2.2 Annotations and colours

As visual representations, annotations are hard to define and to grasp due to the different perspectives from which the topic has been – from psychology, to education, to computer science. For instance, Stefanut and Gorgan (2008) considered annotation as a process that individuals use to analyze and interact with different objects such as documents or images. They included in annotation a series of actions such as making circles around words, underlining portions of text, using colours for text analysis, making corrections on a student paper or using check-marks. On the other hand, Zywica and Gomez (2008) considered annotation as a reading strategy for learning, since it allows better text structuring and marking. Examples are highlighting or drawing signs around important part of the text such as a definition, key content and words.

In spite of the contrasting definitions and the lack of general classifications of annotations, research has addressed annotation both in the area of learning and in the professions. For instance, Heiser and Tversky (2006) identified what they called diagrammatic elements that generally help to enhance understanding of a representation, such as lines, blobs, boxes, crosses, arrows and circles. Elements such as arrows and lines are useful to emphasise the structural organization and functioning of a machine or the working of a body (Azkue, 2013). Another example in engineering showed (see, Eckert et al., 2012) that designers produced drawings using CAD software's and that they create a wide variety of signs and textual annotations that were used to duplicate, juxtapose and overlay images. In the medical field (see, Hartswood et al., 2002) radiographers working with mammograms use different notes to report abnormalities, such as abbreviations like 'BT' for breast tissue or '?' to signal uncertainty. Other examples include 'Dense BT' for dense patches of material, 'X NRC' for no real changes in that area and 'Benign' for benign patches. Generally, these notes are annotated on the screening report, as illustrated in the image below (Fig. 4):

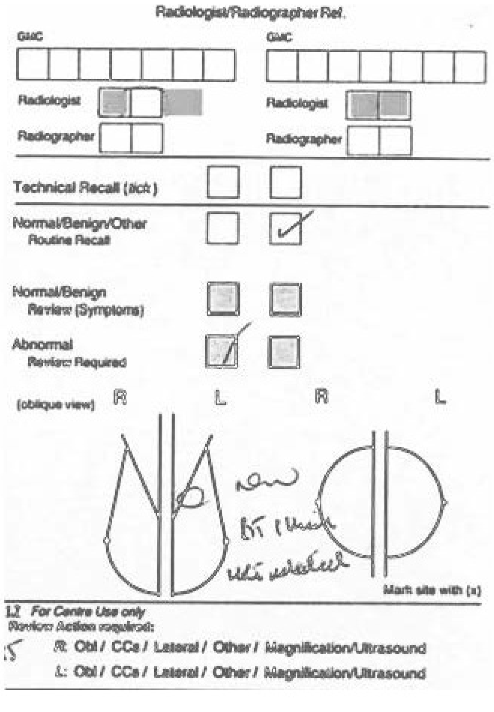

Radiologist/Radiographer Ref.
GMC
GMC
Radiologist
Radiologist
Radiographer
Radiographer
Technical Recall (tick)
Normal/Benign/Other
Routine Recall
Normal/Benign
Review (Symptoms)
Abnormal
Review Required
(oblique view) R L R L
Mark site with (x)
For Centre Use only
Review Action required:
R: Obl / CCs / Lateral / Other / Magnification/Ultrasound
L: Obl / CCs / Lateral / Other / Magnification/Ultrasound

Fig. 4: Section of a mammography screening report (from Hartswood et al., 2012, p.93)

In this study we conceptualise visual representation as a visual object or an image that individuals can create and manipulate such as a mind map, photograph or a sketch. Similarly, we conceive of annotations as the products of a process that includes a series of actions in which a visual representation is manipulated by adding one or more layers of information, which take the form(s) of text, lines, highlights and symbols.

3 Research methodology

To answer our research questions an exploratory study was conducted in the Italian-speaking part of Switzerland (Tessin Canton). Data were collected during 55 semi-structured interviews performed with five professionals from each of eleven professional areas, broadly grouped as: craftsmanship (woodworkers, plumbers, goldsmiths, fashion designers, winemakers, gardeners), industry (chemical technologists, polymechanics technicians, multimedia technicians) and health & services (massage therapists, dental assistants). The interviews lasted for an average of 35 minutes (ranging from 13-90 minutes long) overall. During the sessions, participants were encouraged to show examples of representations and annotations typically used during their everyday work practice; such examples were collected for further reference. All of the interviews were audio-recorded, transcribed and analyzed using NVivo software. A coding scheme was created specifically for this research, based on Pei et al., (see, 2011), Heiser and Tversky (see, 2006), Schraw et al., (see, 2010). The coding scheme was also directly induced from the interviews, to accommodate the fact that many professions included in our study go beyond the area of engineering and design. According to our research aims, the coding scheme distinguishes the following layers of coding: type of visual representation, type of annotation, use of colours and presence of shared language.

Visual Representations includes four codes:

- Drawings are formal arrangements of lines that determine a particular form. Drawings can picture different subjects; they are more structured than sketches;

- Sketches are preliminary design representations of something without details as the basis of a more finished product

- Photographs are images of an object, person or scene recorded by a camera on photosensitive material (Hanks, 1979);

- Other includes any other type of image such as colours scales or chromatographic images.

Annotations are considered to be the result of a series of actions in which a visual representation is manipulated by adding written text, lines, highlights, arrows, drawings, numbers, and so forth (see, Stefanut and Gorgan, 2008; Zywica and Gomez, 2008). The categories of annotations that were observed are the following:

- Notes are organised records of textual information present in a participant's documentation (see, Schraw et al., 2013). This category includes letters and combination of letters (A; AA), numbers (1, 2, 3) and combination of numbers and letters such as measurements (600mm);

- Diagrammatic elements are devices such as lines, blobs, boxes, crosses, arrows and circles (see, Heiser and Tversky, 2006). In this research this category also included plus (+) and minus (-) signs and alphanumeric characters such as asterisks (*), hashtags (#) or at signs (@);

- Symbols (e.g. diameter, hazard symbol, pain) are conventional signs used in writing relating to a particular field to represent operations, quantities, elements, relations or qualities (Merriam-Webster's collegiate dictionary, 1979). They fulfill the criteria of standardization due to being professionally defined in standardised manuals and norms (e.g. International Standards Organization, ISO).

Colour is a layer of categorization that is applied to both representations and annotations. This layer was inserted in the coding scheme since colours is a dimension closely linked to images and annotation (e.g. Marshall, 1998).

Presence of Shared Language is another layer of categorization that can be applied to both representations and annotations. It was coded whenever participants mentioned that a specific representation or annotation was shared within their profession or together with professionals from other professions with which they normally cooperate (e.g. medical doctors and nurses, electricians and plumbers, etc.).A subset equal to 20% of the corpus was independently coded by two researchers. The interrater reliability analyses for the four layers of codes showed substantial agreement that ranged from Kappa=0.75 to Kappa=0.94 (Landis and Koch, 1977).

4 Results

In this section, we will focus on presenting the results of the content analyses of the interviews. Alongside the description of the results, we have provided the illustrative quotation and some of the visual examples provided by the participants.

4.1 What are the types of visual representations used across professions?

Table 1 displays how frequently different visual representations were mentioned by the interviewees, grouped by profession. Drawings were the most often mentioned representations across all professions. Sketches were reported less often than drawings but were mentioned by all the professions. Photos were mentioned by all winemakers, gardeners, goldsmiths and dental assistants.

Table 1: Frequency of references to different visual representations, by profession

	Professions										
Representation	**Wine** *(n = 5)*	**Wood** *(n = 5)*	**Poly** *(n = 5)*	**Multi** *(n = 5)*	**Mass** *(n = 5)*	**Plumb** *(n = 5)*	**Gold** *(n = 5)*	**Gard** *(n = 5)*	**Dent** *(n = 5)*	**Fash** *(n = 5)*	**Chem** *(n = 5)*
Drawings	24 (5)	21 (5)	14 (4)	18 (5)	19 (5)	11 (5)	8 (3)	50 (5)	8 (2)	20 (4)	8 (4)
Sketches	2 (2)	15 (5)	5 (4)	5 (3)	3 (2)	3 (2)	17 (5)	11 (4)	4 (2)	6 (4)	1
Photos	10 (5)	6 (3)	0	1	3 (2)	4 (2)	14 (5)	11 (5)	22 (5)	5 (4)	3 (3)
Other	9 (4)	0	0	1	0	1	0	0	0	0	1

(The numbers refer to the number of times a specific representation was mentioned, the numbers in parentheses standing for the number of persons that mentioned them within each profession)

After looking broadly at the frequencies table, it is important to explore the specific visual representations used by the sample.

In terms of **Drawings**, professionals such as polymechanics technicians and woodworkers reported using mainly technical drawings [1 – see numbered quotes below for examples of the type of use being mentioned] and illustrations [2]. Beside these types, plumbers reported using schematic diagrams [3], which were also the main types of drawing used by multimedia technicians. The difference is that in the first case the representations are picturing hydraulic systems, in the second electronic equipment:

> *[1] "We produce drawings using CAD and its internal library of tools. Our drawings are called 'raiders' and they show all the tools, position, info on the possible connections. With this drawing our workers are able to go to the site of the event with all the info needed." [MultimediaTechnician_P23]*

> *[2] We use technical illustrations of the machines so we know how certain machines work and how they can be cleaned." [PolymechanicsTechnician_P12]*

[3] "They're drawings representing the house. We can see the thermal power station, boilers, pipes, the sanitary systems, counter, and the distribution of the water." [Plumber_P40]"

Fashion designers reported using two types of technical drawings; patterns [4] are templates for tracing the pieces of garments before cutting the fabric and technical sketches [5] are drawings of the garment with defined measurements and information:

[4] "Beside all the other types of images we use patterns. A fashion designer knows patterns. She knows that what is on the table is a jacket and not a dress." [FashionDesigner_P08]

[5] "Technical sketches contain all the information about the garment from start to finish. I know that this garment is from a specific product line, that this jacket has a specific lining and pattern, that I'll need to start stitching from the bottom." [FashionDesigner_P41]

Gardeners' planimetry is a type of technical drawing that shows the outline of the desired garden. It can have multiple formats and these drawings are generally produced by landscape architects [6]. Planimetries are also used by winemakers, who produce them to abide by the canton's regulations or when they need to create a new vineyard [7]. Winemakers also use machine technical illustrations and scientific illustrations depicting plants and disease [8].

[6] "Drawings are made by the architects and then we create the actual garden. We don't make the drawings! These drawings are from the top and show all the different flowerbeds, description of the plants, possible building, walls, pathways and everything else that could be in a garden." [Gardener_P47]

[7] "We make technical drawings depicting the new vineyard since they are required by the canton." [Winemaker_P34]

[8] "I use illustrations during the harvest to show the workers what kind of grapes they have to pick. I also use the plant disease ones to understand what grapes I have to remove." [Winemaker_P42]

Dental assistants and massage therapists reported using evaluation forms representing the body, called dentition charts and body charts. Dentition charts [9] are currently digital images presented in software (e.g. ZaWin32 or OneBox) depicting a prototypical set of teeth that can be modified by the assistant to match that of the patient. Similarly, body charts [10] depict the whole body or specific body parts. They both also reported using scientific illustrations of the body or the mouth [11]:

[9] "The software has many settings. You can add all the different types of cavities and fillings, the pathology, the type of prostheses, implants or retainers that the patient has. You can also draw or write a note about a broken tooth or if the crown is made of gold or ceramic." [DentalAssistant_P26]

[10] "We use images representing the mouth with descriptions of different sections of the tooth. They are useful to explain to patients what type of treatment they are going to experience." [DentalAssistant_P26]

[11] "Anatomy books are useful to explain things to patients." [MassageTherapist_P10]

Finally, the main source of information for chemical technicians was not graphical but rather text-based, and the only types of drawings used were technical drawings representing machines [12]:

[12] "Drawings can help with the machines. It's rare but if machines do not work we need them to fix the problem!" [ChemicalTechnician_P01]

Sketches are often created to put some ideas on paper and to show or explain something to the client. Therefore, sketches are simple visualizations of the possible product (e.g. jewelry). In the case of industrial and craftsmanship professionals, such as polymechanics technicians, woodworkers, multimedia technicians and plumbers, sketches can take the form of idea, study, informative or prescriptive sketches (see, Pei et al., 2011) and are used as a starting point to build the required piece [13], multimedia installation [14] or sanitary installation:

[13] "We always use them when building parts. If someone asks for a simple part such as a hook we sketch it and we don't waste time with the technical drawings. We start working directly from the sketch." [PolymechanicsTechnician_P12]

[14] "Sketches created in the first meeting with the client are the 'phase zero' of the project. They might look like unintelligible doodles but they are just the initial phase and they include also the 'emotional side' or the 'fil rouge' of the event." [MultimediaTechnician_P23]

Goldsmiths favored sketches over drawings; they produce idea and study sketches in which they try different versions of the jewelry to be shown to the client before starting to work on the precious material [15]. In case of complex jewelry they produce a sketch with counts and measurements [16]:

[15] "I make simple sketches with a pencil in black and white. In other cases, it's the client that brings me some drawings and I just try to redraw it a little better. Typically clients are happy with the result." [Goldsmith_P24]

[16] "Well, if I have to make very complex jewelry or if I have to do something difficult." [Goldsmith_P13]

Gardeners produced simple planimetry sketches (prescriptive sketches), but if the project was extensive, they required technical drawings from architects [17]. If the project was extensive or well-financed, they might ask architects or artists to produce renderings of the final results. Renderings were also used by woodworkers and multimedia technicians [18]:

[17] "The idea is always to start with a small sketch in pencil that can be understood by everyone. Then it depends, if you're a private client we just talk and we find a solution together by showing them some simple sketches on the spot. While if it's a big building with 30 apartments, there is typically a company and architect involved and they'll give us proper drawings." [Gardener_P53]

[18] "Renderings are useful to interpret the client's desire since they show the emotional aspect of what we're going to build and help in showing the technical drawings in a realistic form." [MultimediaTechnician_P23]

Dental assistants and massage therapists reported using information sketches to explain something to the patient [19]. Winemakers produced sketches only when designing a new vineyard [20]:

[19] "I rarely use them, but in some cases I'll use them to show what a hernia or a nerve compression looks like." [MassageTherapist_P10]

[20] "We use sketches that look like planimetry to understand how big the vineyard will be, how many plants I'll need, how many poles and all the rest of the materials." [Woodworker_P57]

Fashion designers reported using another type of sketch called measurement tables [21] that include a sketch of the final dress and its measurements:

[21] "It's a standard table in which all the main measurement such as chest, waist and hips are reported. We also add simple and quick sketches so the client can have an idea of the dress." [FashionDesigner_P08]

In terms of **Photographs**, the only two types identified were photos taken with a camera or a phone and x-rays. In general, massage therapists reported taking snapshots of the patient's body to show the status of the healing process [22]. Dental Assistants used them to clarify information given by the dentist and also used panoramic and single x-rays [23]:

[22] "Some chronic patients are unable to see their progress. In the case of an edema, I put photos next to their body to show their progress." [MassageTherapist_P03]

[23] "We do panoramic x-rays but we can also look at the status of the teeth with 12 or 14 single x-rays that are more accurate. X-rays help us see if bones are retracting and there's risk of periodontal disease." [DentalAssistant_P16]

Also, professionals such as fashion designers, goldsmiths and gardeners reported that they take or find photos to use them as inspiration or reference sources for a dress, a piece of jewelry [24] or a garden [25]:

[24] "Typically when clients come to my shop I show them photos from website or I can find other examples online." [Goldsmith_P32]

[25] "I use photos of plants and reference images of previous work done on retaining walls and other plantings." [Gardener_P05]

Chemical technologists reported that they simplify a procedure by displaying photos of the machines they must use [26]:

[26] "I write instructions for analyses and I use photographs to show the machines to be used in a specific procedure; in this way, they all understand." [Chemical Technologist_P49]

In the case of plumbers, photos were used to remember to pay attention to certain things when installing or while building something such as a hidden pipe/tube [27]:

[27] "We take pictures of the bathroom and the furniture. If I have to install a tube that is behind the furniture I need to install it correctly or the furniture won't open properly." [Plumber_P54]

Winemakers reported using photos to learn new techniques and to identify the presence of diseases in the vines [28]:

[28] "I use images when I need to check the health of the vine." [Winmeaker_P39]

The last category, **Other**, is the least represented in the sample; it includes mentions of other types of representations such as graphs for multimedia technicians, pH scales for winemakers, chromatographic images for the chemical technologists [29]:

[29] "I use chromatographic images that show the results to achieve with the solution." [Chemical Technologist_P05]

4.2 What are the types of annotations used across professions?

Table 2 displays how frequently different types of annotations were mentioned by the sample, grouped by profession. Notes were strongly mentioned by members of all of the professions. Similarly, Symbols are present in the remarks of all of the professionals but were rarely mentioned by massage therapists, goldsmiths and fashion designers. The use of Diagrammatic Elements was less frequently mentioned; however, they are nevertheless referred to by all of the massage therapists and fashion designers interviewed and by all but one of the woodworkers. That revealed an interesting language of profession-specific diagrammatic elements.

Table 2: Frequency of references to different annotations, by profession

	Professions										
Annotations	**Wine** *(n = 5)*	**Wood** *(n = 5)*	**Poly** *(n = 5)*	**Multi** *(n = 5)*	**Mass** *(n = 5)*	**Plumb** *(n = 5)*	**Gold** *(n = 5)*	**Gard** *(n = 5)*	**Dent** *(n = 5)*	**Fash** *(n = 5)*	**Chem** *(n = 5)*
Note	7(4)	30(5)	14(4)	8(4)	29(5)	16(5)	23(5)	31(5)	22(5)	31(5)	6(3)
Symbol	7(3)	14(5)	12(4)	18(5)	1	13(5)	2(1)	14(5)	9(5)	0	12(5)
DElem	0	9(4)	0	1	35(5)	3(2)	2(2)	11(3)	1	16(5)	1

More specifically, in terms of **Notes**, professionals such as polymechanics technicians, plumbers, woodworkers, multimedia technicians, and fashion designers all produced notes that included information such as general type of processing (e.g. surface roughness) [30], scheduling of the work, presence of errors, information about the materials and measurements [31]. Gardeners and winemakers created notes with information about the status of their plants and possible diseases [32]:

[30] "We write description of the processing such 'flat, laminated, 600X400mm and 105mm long with a surface roughness of 12.5'. Also the numbers 1 and 2 next to the measurements indicate edits to the original drawing." [PolymechanicsTechnician_P46]

[31] "We received sketches from the headquarters with fabric samples. They include all sort of notes and measurements and also a description of the prototype indicating type of stitching, type of button, the length of the fabric used and much other info." [Fashion Designer_P33]

[32] "We walk in the vineyard, observe and write down that some grapes are almost ready or that some vines are most resistant or mature faster than others. We take notes and then we reproduce that vine." [Winemaker_P57]

Similarly, goldsmiths indicated the type of material to use, colours of the stone, type of effect such as glazing and rhodiation, measurements of both the client's body and the materials (e.g. stones) [33]. They also included different type of abbreviations [34]:

[33] "I write down the measurements of the fingers or other measurements of the client's body, the width needed and the type of processing for the metal." [Goldsmith_P32]

[34] "For the material I can write AU (aurum) for gold and if the jewel is made of white gold I'll write WG." [Goldsmith¬_P30]

Dental assistants produced notes that include standardised descriptions [31] of the status of the mouth or the procedure to perform [35]:

[35] "The doctor can write that the cavity is mesio-occlusal with the abbreviation 'MO' or 'DO' for distal-occlusal. For the dentition numeration we use 1, 2, 3 and 4 for the quadrants so if we remove the 8th tooth from the first quadrant I'll write '1.8 removed'." [DentalAssistant_P16]

Chemical technologists produced internal warnings and instructions about the functioning of the machines or the procedure itself, but these are generally discouraged [36]:

[36] "We have personal notes in which we write tips like waiting a certain time for a machine to be ready, but this info is not in the procedure. These notes create doubts so they are only in our notebooks." [Chemical Technologist_P05]

In the case of **Diagrammatic Elements**, fashion designers used them to signal where to sew parts together [37]. Depending on the design studio, dotted/straight lines might indicate different type of bindellos (tapes) or show where to shrink/tighten, wrinkle, and cut/sew the fabric [38]. Also, gardeners used cross signs to show where already existing elements such as plants or the irrigation system are placed [39]:

[37] "I use a cross and another signal that means I have to sew the pieces together." [FashionDesigner_P08]

[38] "Printed dotted lines indicate where to sew, while straight lines indicate where to cut." [FashionDesigner_P33]

[39] "I use an cross to indicate where the irrigation system is." [Gardener_P47]

Massage therapists reported extensive use of diagrammatic elements such as circles, zigzags, hashtags, numbers, dots and plus and minus signs to indicate areas of pain, trigger points and other pain-related symptoms. Sometimes they re-draw a part of the body to make it more similar to that of the patient. Other signs included asterisks for scars and arrows for hyperextensions or rotation of the neck or hip [40;41]:

[40] "I use numbers to indicate where the problem is and I use circles to indicate the pain areas. I also use plus and minus signs to indicate the level of pain." [MassageTherapist_P09]

[41] "I use a cross to indicate crossing knees. I redraw the shape of the spine on the body chart to make it similar to the patient's actual spine if they have lordosis or it it's too straight. I also use a hashtag for a scar." [MassageTherapist_P03]

Dental assistants seem to be different from all the other professionals, because most of the paper dentition charts have been replaced by software with digital dentition charts. This means that they use software to mark (by selecting from a menu) the status of the teeth [42]:

> *[42] "You can do anything with the programs; add implants, prostheses, retainers or other info, like if we need to change the filling." [DentalAssistant_P26]*

Polymechanics technicians use lines to signal errors in the drawings [43]:

> *[43] "I can only annotate where there is an error. I have to open the file in the program and change it with a red line, sign it and sent it to the engineer." [Polymechanics_P18]*

The professionals in our sample used various types of **Symbols**. Woodworkers, for instance, reported using technical symbols such as the radius or diameter, but also other symbols specific to their profession such as the presence of invisible elements (e.g. glass) or others that differentiate between types of woods or types of openings in a window [44]:

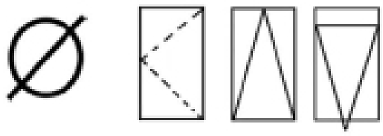
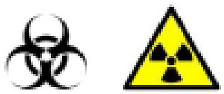
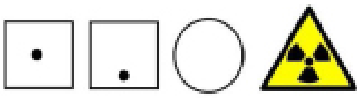
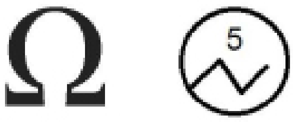
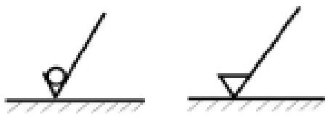
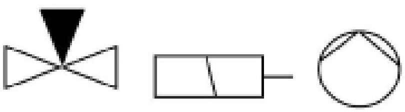
> *[44] "Triangles are conventional signs that indicate the location of the top, bottom, right and left sections of pieces of furniture to assemble. Lines indicate the opening direction of the window." [Woodworker_P14]*

Chemical technologists reported using biohazard and 'risk and safety' symbols. Hazard symbols were also used by winemakers and dental assistants; the latter also used symbols describing the status of the teeth (e.g. square with dots). Plumbers also used standardised symbols (International Organization for Standardization [ISO], 2016) to indicate the water direction and different mechanical components [45]:

> *[45] "We use specific signs. A triangle with a circle is a pump, a butterfly-looking sign is a valve and the arrow with a circle is a manometer." [Plumbers_P37]*

Goldsmiths performing gem certification reported using standardised symbols (from Gemological Institute of America) to mark issues of the stone. Multimedia technicians pointed out that they use CAD-CAM programs that already contain symbols for all the components of an electrical diagram such as the socket, aerials and use measurement units (e.g. decibel). They use standardised symbols identifying aerials, channels and transformers but also codes like the American Standard Code for Information Interchange (ASCII) the National Television System Committee (NTSC). Polymechanics technicians use standardised symbols in their technical drawings in conformity of ISO and DEN norms that can be found in "Extrait de normes pour écoles techniques" (Verein Schweizerischer Maschinenindustrieller, 1991). Other symbols are those for surface roughness that indicate the type of processing of the metal. Examples of some of the symbols reported to be used by the participants are shown in Table 3:

Table 3: Examples of the main symbols mentioned by specific professions

Professions	Symbols	Purpose
Woodworker		Use of mathematical symbols and woodworker-specific symbols (e.g. window opening)
Chemical Technologist		Bio-hazard symbols
Winemaker		Bio-hazard symbols
Dental Assistant		Use of squares (position of cavity), circles (amalgam fillings) and bio-hazard symbols
Multimedia Technician		Use of mathematical and electrical drawing symbols representing measurements and equipment
Polymechanic Technician		Use of mathematical technical drawing symbols (e.g. VSM) representing tolerances and texture of the industrial process (e.g. surface roughness)
Plumber		Use of technical symbols representing valves and other sections of the piping system

4.3 What are the colours used across professions?

In Table 4, it can be observed that almost all the professions had multiple verbalizations regarding the use of colours in their representations or their annotations.

Table 4: Frequency of references to different colours, by profession

	Professions										
	Wine *(n = 5)*	**Wood** *(n = 5)*	**Poly** *(n = 5)*	**Multi** *(n = 5)*	**Mass** *(n = 5)*	**Plumb** *(n = 5)*	**Gold** *(n = 5)*	**Gard** *(n = 5)*	**Dent** *(n = 5)*	**Fash** *(n = 5)*	**Chem** *(n = 5)*
Colours	4(3)	7(5)	8(3)	7(5)	10(4)	15(5)	7(4)	9(5)	8(4)	6(4)	3(3)

Nevertheless, the category **Colours** was not used extensively, and most participants indicated that their drawings or sketches are often in black and white [46;47] even if there are some exceptions. For instance, plumbers colours pipes in red (hot water/high pressure), blue/green (cold water) or brown according to what they contain (e.g. drained water) while drains for the refrigeration system are sometimes marked in purple [48]. Multimedia technicians also have standard colours (International Electrotechnical Commission [IEC], 2017) such as red, yellow, green, brown and black to differentiate cables [49]:

[46] "Sketches are in black and white, but I can use some color for a specific client for the color of the stones." [Goldsmith_P13]

[47] "Drawings are mostly monochromatic. Colored lines and colored codes can be useful in complex drawings." [ChemicalTechnologist_P01]

[48] "In general, hot water is in red while the return water is in blue. Blue is for high pressure water, green is for cold water and red or pink is for hot water." [Plumber_P40]

[49] "Cables' colours can be black, brown and red. In the case of microelectronics, colours are now printed numbers." [MultimediaTechnician_P44]

Massage therapists reported using colours to indicate problematic areas in body evaluation forms [50] while dental assistants used them to differentiate pathologies, and to flag important info to communicate, symbols and notes about surgeries [51]:

[50] "I write notes in red to indicate surgeries." [DentalAssistant_P16]

[51] "I use red and blue to highlight the problem. I can use red for areas of pain, while areas of tension are in blue. Red is also for trigger points." [MassageTherapist_P09]

4.4 Illustrative examples

In this section are displayed some of the images collected during the interviews. From these examples it is possible to observe the different layers of observation used in the research and how they are all integrated in the images. For instance, massage therapists mainly use evaluation forms on which they put annotations such as notes, arrows and lines and colours like red (Fig. 5).

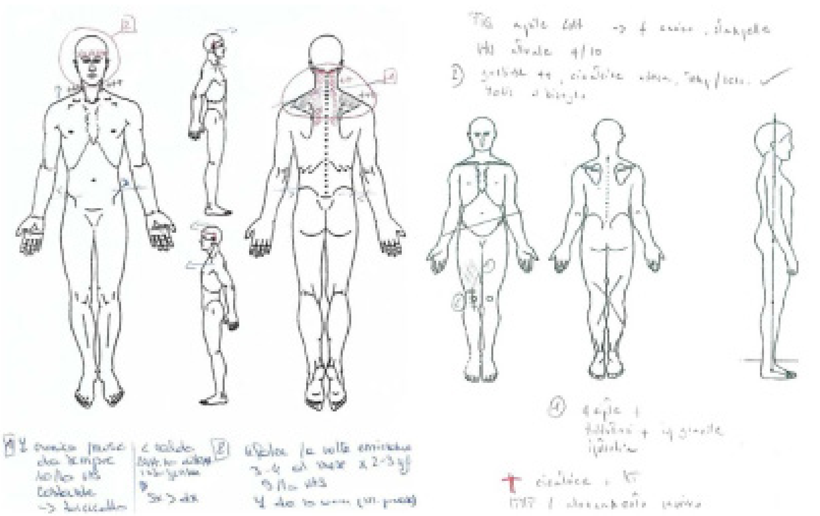


Fig. 5: Evaluation charts

Fashion designers' use of images is chronological. First they produce a table with measurements and a sketch of the possible garment (Fig. 6). Then, they produce drawings called technical sketches that show the final design. And ultimately they use patterns that are the definitive technical drawings of the pieces composing the garment, with notes and diagrammatic elements indicating the name of the piece and the cutting/sewing lines (Fig. 7).

Fig. 6: Different forms of measurement table

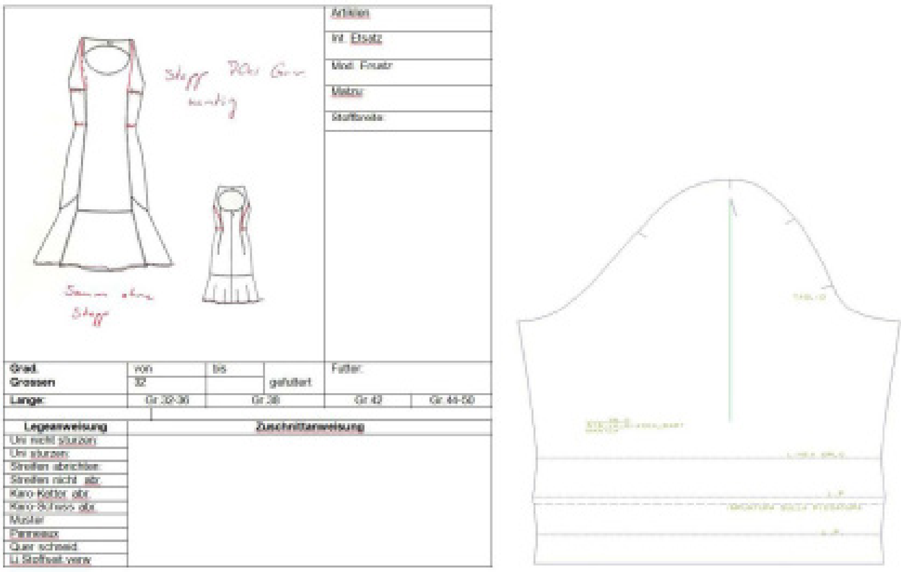


Fig. 7: Technical sketch (left) and Pattern (right)

Goldsmiths use sketches to try out different concepts for the final look of the jewelry; in the case of a complex piece of jewelry they produce sketches with measurements, calculations and symbols (Fig. 8).

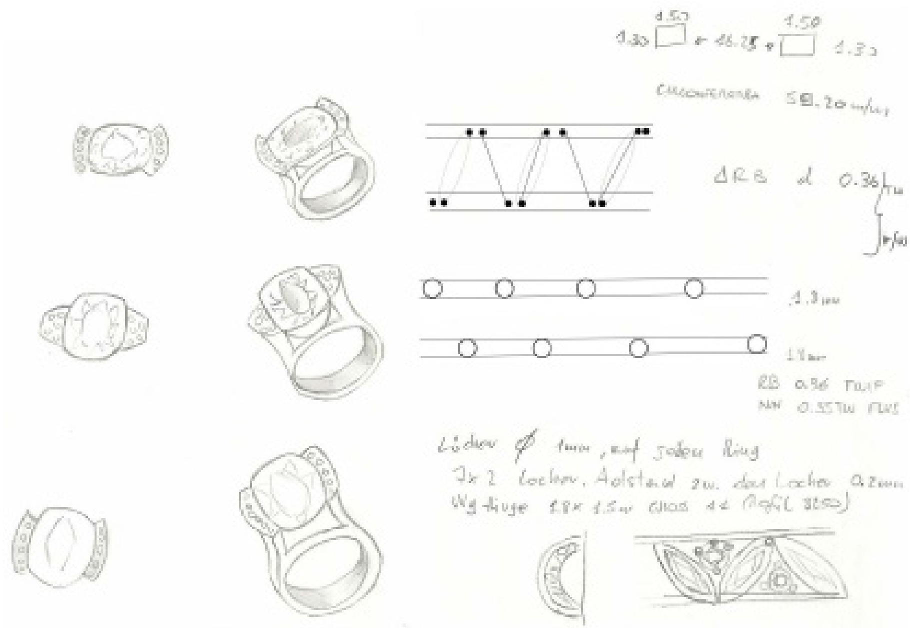


Fig. 8: Sketches of a ring and a bracelet

Plumbers produce sketches (Fig. 9) of the plumbing system with symbols and notes and then a technical drawing with specific colours for the different types of pipes and standardised symbols (Fig. 10).

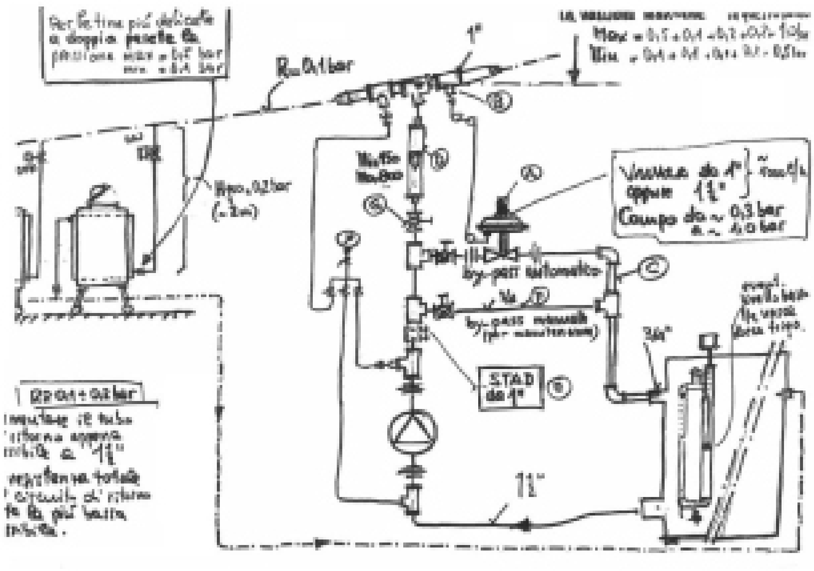


Fig. 9: Sketch of a plumbing system

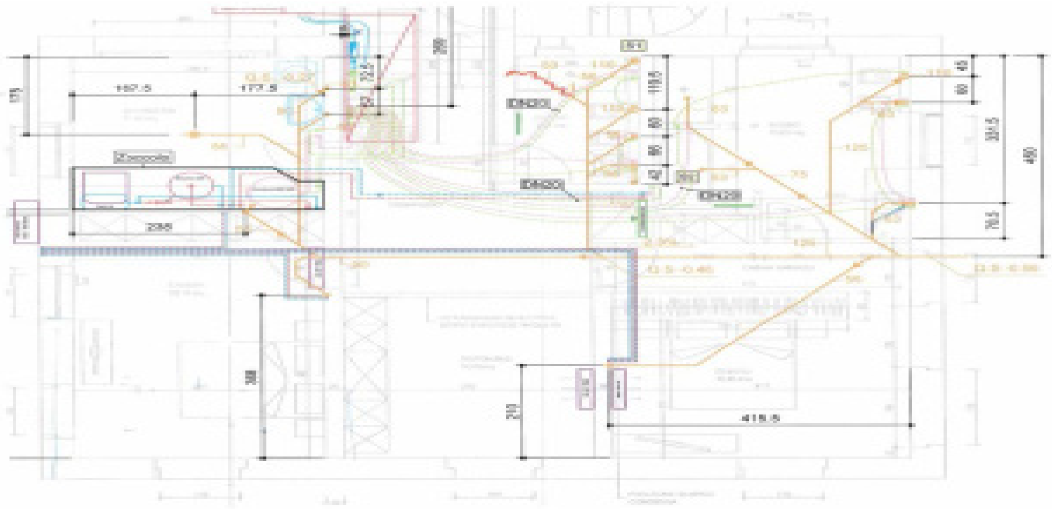


Fig. 10: Technical drawing

Gardeners produce sketches in the form of planimetries with notes, diagrammatic elements and colours (Fig. 11). They also use technical planimetries that are colored and that incude symbols indicating differen type of plant (Fig. 12). Furthemore, they also employ other professionals to produce paintings called renderings (Fig. 13).

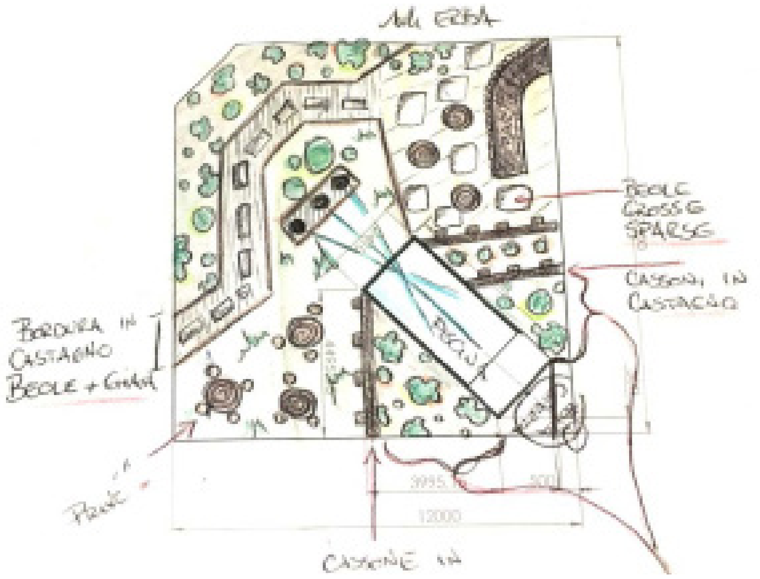


Fig. 11: Planimetry sketch

Fig. 12: Planimetry drawing

Fig. 13: Rendering

Woodworkers use different types of technical drawings with different perspectives that include notes, diagrammatic elements and symbols (Fig. 14).

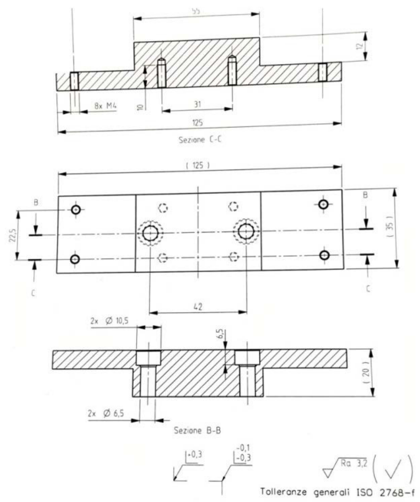


Fig. 14: Technical woodworking drawing

4.5 Is there any evidence of a shared visual language in the professions?

Table 5 shows important differences in the use of shared visual language across the professions. Technical profession such as woodworkers or plumbers mentioning it more that non-technical ones such as winemakers or goldsmiths.

Table 5: Frequency of references to presence of shared language, by profession

	Professions										
	Wine *(n = 5)*	**Wood** *(n = 5)*	**Poly** *(n = 5)*	**Multi** *(n = 5)*	**Mass** *(n = 5)*	**Plumb** *(n = 5)*	**Gold** *(n = 5)*	**Gard** *(n = 5)*	**Dent** *(n = 5)*	**Fash** *(n = 5)*	**Chem** *(n = 5)*
Shared Language	1	16(5)	5(3)	8(4)	4(4)	11(4)	2(2)	3(3)	6(4)	4(4)	3(2)

More specifically, it was observed that members of professions characterised by the use of technical material, such as woodworkers, plumbers, polymechanics technicians and multimedia technicians, share similarities in their visual language both within [52;53] and between [54;55] their professions. This is mainly due to the need of using standardised norms and regulations such as ISO norms (Internal Organization for Standardization [ISO], 2003;1989) that consequentially enforce the use of standardization in the images:

[52] "We didn't invent them! It's a convention! If you go to another plumber he'll know that hot water return piping is marked in red and the cold water ones in blue." [Plumber_ P40]

[53] "We share the drawing style. At school we used the same norms and symbols. Companies might be a bit different from each other but the standard is still the same." [Woodworker_P06]

[54] "The measurement standard that we use is SWISS, EU or USA since we work with national and international companies." [PolymechanicsTechnician_P12]"

[55] "Technical drawings are technical drawings regardless of being from a woodworker, electrician or a bricklayer." [Woodworker_P14]

Chemical technologists are in a similar situation since their language is shared internationally due to their products being sold worldwide [56]. Their work is regulated by standardised documentation such as the one used in the production of medication (European Pharmacopoeia Commission and European Directorate for the Quality of Medicines and Healthcare, 2010):

[56] "Procedures are national but the analyses are codified in USA, EU or internationally depending to where we market the product." [ChemicalTechnologist_P21]

Clinical-related professions such as massage therapy and dental assisting both have similar visual languages since they use evaluation forms for the teeth or the body on which they mark health issues, add symbols and write notes about the treatment and status of the patient [57]:

> *[57] "Evaluation charts are used even by doctors, physiotherapists and massage therapists and osteopaths. If I have to communicate with them I'll use body charts." [MassageTherapist_P04]*

Another profession with shared language is that of gardeners, since they borrow symbols from landscape architects [58] and, depending on the type of work, share responsibility in the creation of the representation [59]:

> *[58] "These symbols are official between the architects. They have symbols for everything!" [Gardener_P53]*

> *[59] "We do some measurements on the spot and we give them to the architect who will make the technical drawing and the we carry it out in the garden." [Gardener_P55]*

Specifically this result indicates that all of the professions produce notes that are similar in content, which focus mainly on the scope, materials, and schedule of the work. The main types of Diagrammatic Elements used are cross signs, lines and arrows. In terms of Symbols, the ones shared between the professions are technical ones such as radius or diameter, while within the professions other symbols are shared, such as the one for surface roughness used by the polymechanics technicians or the ones indicating different types of wood used by the woodworkers. For the feature of Color, there is shared language between the technical professions, since they all produce black and white drawings, but also within professions, such as the use of color coding of the electrical cables for the technicians or color differentiation in the hydraulic systems for plumbers.

5 Conclusion and discussion

The aims of this research were to explore the visual language of vocational professions by identifying the types of visual representations and annotations used and also to find evidence of a shared visual language. Unlike previous research that focused mainly on specific types or branches of professions (e.g. Pei et al., 2011), this study deliberately included a large variety of vocational professions. With respect to our first question, it is possible to conclude that the professionals in the sample make use of different types of visualizations in their professions, such as many different types of Drawings (e.g. technical drawings, evaluation forms or schematic diagrams), Sketches (e.g. technical sketches or prescriptive sketches), Photos and other forms of visual representation (e.g. chromatographic images). In terms of annotations, the most frequently used type is Notes, which are present across all professions, and have a similar purpose and content. Other types are Diagrammatic Elements such as arrows and lines, which are mainly used by fashion designers, dental assistants and massage therapists. There are also Symbols that are used extensively in the form of standardised technical symbols (e.g. radius) and profession-specific symbols (e.g. surface roughness).

In terms of the second question it is possible to conclude that shared language is present both within and between the professions, but the level of sharing might be different from profession to profession or according to a type of specific representation or annotation. For instance, for standardizations reasons, technical and clinical professions possess a specific language that is shared both within and between their communities. A technical drawing of a building can be read by plumbers, multimedia technologists and woodworkers. In other professions, such as fashion design, they have their own specific language that is mostly not shared outside the profession.

The results of this research could be relevant for VET by helping educators to design courses and activities more in line with real working practices. Specifically, the results pointed out the strong presence of visual representations in a variety of different professions, but also indicated that annotations are fundamental, such as in the case of the massage therapists and fashion designers. VET is an essential part of the education system in Switzerland, but there are still some gaps to fill and some progress to be made in order to create cohesive and better integrated experiences for students who move across different learning environments such as schools, companies and branch-courses. For instance, the pedagogical model 'Erfahrraum' (Schwendimann, Cattaneo, Dehler, & Zufferey, 2015) can be used for designing activities aimed at the integration of knowledge and professional skills. Examples in this direction are the work of Cattaneo, Motta and Gurtner (2015) with chefs or studies such as the one from Caruso (2017) that identified how fundamental observational skills are for fashion designers and the potential of developing a training program to promote this ability. Along this line, further research will continue to explore representations and annotations in vocational education, the possibility of developing e-tools to build students' visual abilities with the help of representations and annotations and, at the same time, the development of an educational scenario to provide better integration between school and workplace.

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ORIGINAL PAPER

Effects of Experts' Annotations on Fashion Designers Apprentices' Gaze Patterns and Verbalisations

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Abstract

Visual expertise is a fundamental proficiency in many vocations and many questions have risen on the topic, with studies looking at experts and novices differences' in observation (e.g., radiologists) or at ways to help novices achieve visual expertise (e.g., through annotations). However, most of these studies focus on white-collar professions and overlook vocational ones. For example, observing is uttermost important for fashion designers who spend most of their professional time on visual tasks related to creating patterns and garments or performing alterations. Therefore, this study focuses on trying to convey a professional way to look at images by exposing apprentices to images annotated (e.g., circles) by experts and identifying if their gaze (e.g., fixation durations and gaze coverage) and verbalisations (i.e., images descriptions) are affected. The study was conducted with 38 apprentices that were exposed to sequential sets of images depicting shirts, first non-annotated (pre-test), then annotated for the experimental group and non-annotated for the control group (training 1 and training 2), and finally non-annotated (post-test). Also, in the pre and post-test and in training 2 apprentices had to verbally describe each image. Gaze was recorded with the Tobii X2–60 tracker. Results for fixation durations showed that the experimental group looked longer in the annotated part of the shirt in training 1 and in the shirt's central part at post-test. However, the experimental group did not cover a significantly larger area of the shirt compared to control and verbalisations show no difference between the groups at post-test.

Keywords Visual expertise · Gaze · Annotations · Fashion designers

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Introduction

The professional world is in constant evolution and, inevitably, the field of education must remain up-to-date by attempting to prepare students for a hyper-specialised and technology-driven world. Numerous transversal skills are necessary to thrive in an ever-changing professional environment (Pang et al., 2019)—both personal and interpersonal or emotional skills (Srivastava, 2013), as well as other more specific skills like visual expertise, are indispensable for certain professions (Jasani & Saks, 2013; Kok et al., 2017); Naweed & Balakrishnan, 2014; O'Halloran & Deale, 2006).

Observation has long been studied from various perspectives. From a sociological point of view, it can be considered interconnected with expertise: observation is a shared perception of the world that is visible in specific shared actions (e.g., using coding schemes) within a professional community (Goodwin, 1994). From a more cognitive perspective, it can be viewed as a set of visual skills that are specific to each task and domain and require interaction between perceptual and cognitive skills (Ravesloot et al., 2012).

Examples of such skills include visual search and visual information processing to detect and interpret lesions in X-rays (see Ravesloot et al., 2012) or to recognise specific patterns, such as presence of symmetry, colours, and shapes in radiology (Shapiro et al., 2006). The ability to use global and local processing of image features in arts (Chamberlain & Wagemans, 2015) or the skills to identify specific students' behaviours in class for teachers (Stürmer et al., 2013) constitute other examples of such skills. The importance of visual expertise makes it a topic that is studied in numerous contexts, such as medicine (Naghshineh et al., 2008), architecture (Styhre & Gluch, 2009), and sports (Kredel et al., 2017). Most of these studies focus on understanding the differences between experts and novices, either to distinguish where they focus their attention while looking at professional material or investigate how to improve observation skills of novices. In this latter case, the strategy is often to redirect novices' attention using annotations (or signals or cues) in the form of arrows, text, audio, colours, etc. (Schneider et al., 2018).

However, studies on observation have rarely been explored within vocational education, although some examples are worth investigating. For instance, fashion designers are certainly among those vocational professions that strongly rely on visual expertise. In Switzerland, fashion designers have a dedicated full-time and dual (part-time school and part-time in the workplace) Vocational Education and Training (VET) course. During their three years' training, they have to engage with tasks like production of sketches, production and alteration of patterns, knowledge and use of fabrics, styling of clothing, and production and alteration of garments both by hand and using professional machines. Apprentices have to acquire a wide range of skills to work in the sartorial world, of which visual expertise is one of the most important since they have to learn how to observe different representations of garments such as photos, technical sketches, or patterns (Coppi et al., 2019) and garments themselves. More specifically, looking at their training plan (State Secretariat for Education, Research and Innovation, Fashion Designers' Training Regulation, 2018), it emerges that in order to become an acknowledged professional they must develop the competence to observe different details (e.g., specific manufacturing, types of pockets, garment opening types, types and quality of fabric), defects (e.g., defects of proportions, wearability, manufacturing quality) and characteristics of the customer's body (e.g., posture, shape irregularities to hide or enhance) (see Caruso et al., 2017). At the same time, looking at their learning activities, they have to develop their competence to make their observation skills explicit when professionally describing a garment to become an acknowledged professional (Caruso et al., 2019).

This paper aims to address the above-mentioned research gap by investigating how visual expertise can be fostered in apprentice fashion designers. This profession can be ideal for creating experimental set-ups specific to the many tasks that apprentices have to perform and to convey a professional way to look at profession-specific images using cueing methods. In particular, this study intends to tackle the following two research questions:

- Can exposure to annotations convey a professional way to look at images in terms of fixation durations and gaze coverage?
- Can exposure to annotations affect the way apprentice describe professional images?

Visual Expertise and Eye Movements

In order to understand how to convey a professional way of looking at images, some background information is needed about eye movements' parameters and how they relate to expertise.

Among the main types of eye movements, the most used are fixations and saccades. Fixations are the period of time when the eye is relatively still (Holmqvist et al., 2011) and reveal where a participant's attention is allocated on a specific stimuli (or parts of the stimulus). Saccades are quick and simultaneous movements of the eyes between fixations in the same direction (Cassin et al., 1984) and they help in understanding the direction of the gaze and if targets attract attention. These types of eye movements are fundamental to research on observation since difference in expertise can be seen in both of these parameters but mainly in fixation durations.

For instance, expert gymnastic coaches show fewer but longer fixations on an athlete's body compared to novice coaches (Moreno et al., 2002); similarly, expert swimming coaches spend more time fixating on swimmers' movements (e.g., body-roll) compared to their novice colleagues and specific body parts (e.g., hands and head) when the swimmer is entering the water (Moreno et al., 2006). Similarly, climbing experts had fewer but longer fixations on a climber's body (core and feet and feet placements) with more and shorter fixations on other parts of the body (hands) compared to novices (Mitchell et al., 2020).

In the medical field, experts spend their time fixating on areas of high saliency compared to novices, while students have generally prolonged saccades on the entire image (Krupinski et al., 2006). More recently, Krupinski et al. (2014) trained dermatologists in reading benign and malign close-up dermoscopy images and showed that a dermatologist tends to have more efficient search with fewer fixations and longer dwells (‘one visit in an area of interest, from entry to exit’; (Holmqvist et al., 2011, p. 190). Further, in radiology, Wood et al. (2013) found that experts are quicker than novices in identifying fractures and spent more time fixating on them. In addition, experts draw conclusions based on observed abnormalities instead of focusing directly on pathologies like novices do (Jaarsma et al., 2014).

In biology, Jarodzka et al. (2010) indicated that in a fish locomotion task, novices had longer viewing times on irrelevant areas, while experts had longer gaze durations on the features of fish and also provided richer verbal descriptions of the fishes’ movements. In education, expert teachers were better able to perceive class interactions by generally visiting and revisiting specific areas, gazing at a student’s body, and at sections of the class with more physical and verbal interaction between students (Wolff et al., 2016).

Generally, regardless of the field, it seems that visual expertise appears to rely on three main elements: 1) being able to identify more quickly the task-relevant areas of the image; 2) spending more time observing relevant features (e.g., fracture in X-ray) and less time on irrelevant ones (e.g., tender tissues in X-ray); and 3) being more cognitively activated, that is, showing higher content evaluation and understanding of the images viewed. Also, as another measure for expertise, 4) the expert should be able to verbalise more technical terms and more features related to the task compared to novices.

Strategies for Improving Visual Expertise and the Role of Annotations

Research did not stop at identifying the differences between novices and experts but also attempted to understand how to improve observation in novices to make them observe more like an expert. Most of these studies draw their theoretical basis from the concept of signalling that, according to Mayer (2002), is the process of presenting cues in an effective manner so that students can easily select—and then process—instructional material better. Signals are placed in the most significant areas of the learning material (e.g., text or image) to redirect students’ attention and to make certain areas more salient than others. This can result in lower cognitive load, more focused attention, and better comprehension and retention (Dodd & Antonenko, 2012; Richter et al., 2016).

Cues, signals, or annotations can have multiple forms—colours, text-picture reference, gestures, labels, flashlights, graphic organisers, and diagrammatic elements such as lines, blobs, boxes, crosses, arrows, circles, and transparent overlay (Heiser & Tversky, 2006; Shin & Park, 2019; van Gog, 2014). For example, coloured indicators can help participants with low spatial skill in solving mental rotation tasks (Roach et al., 2019). Also, translucent colour patches were used in golf training videos to show novices the correct movement to adopt to improve their performance (D’Innocenzo et al., 2016). Others used a spotlight method and applied shades of colour to specific sections of a medical image and were able to induce in novices longer fixations on cued areas compared to non-cued ones (De Koning et al., 2007).

Moreover, the use of lines or arrows have proven useful. For example, arrows applied to an animation displaying the functioning of a piano increased the attention towards relevant sections and resulted in better comprehension of the movements of the piano keys (Boucheix & Lowe, 2010). In others, circles and colours were used to improve the diagnostic performance and visual processing of novice radiologists by showing participants radiographies with relevant parts highlighted with yellow circles, shading on irrelevant areas, and use of colours to highlight the lines of the fractures (Scheiter et al., 2019).

Assuming that experts (e.g., radiologists) tend to observe the most important areas (e.g., lesion) of an image (e.g., X-ray), other scholars used dots positioned on the material to replicate the eye movements of an expert as modelling cues. In this manner, learners are exposed to an expert's gaze pattern under the hypothesis that they will implicitly learn where to look and, hopefully, replicate the pattern in other materials. A pioneering study in this area was performed by Grant and Spivey (2003), and exposed participants to the annotations modelled on the gaze of an expert to highlight sections of a problem-solving task, helping students find the solution. Other scholars asked novice marine biologists to watch and listen to a video showing a fish moving in the water and identify the types of movement it made. The video contained annotations based on the eye movements of an expert that helped novices focus on a section of the body of the fish to identify the movements of the fish (see Jarodzka et al., 2010, 2013). Further, Sharma et al. (2015) superimposed teachers' gazes on an educational video and helped students have a more linear experience, better understanding of the teacher's gestures, and higher engagement. Similarly, Mason, Pluchino, Tornatora, and Ariasi (2013) showed participants the models' eyes in the form of red dots on a text with graphics and noticed that learners spent more time re-fixating on the relevant parts of the visualisation while reading and performed better than control in a recall test.

Hypotheses

Based on the above-mentioned literature, annotations appear to be an effective technique for promoting visual expertise, often combined with eye tracking techniques. Consequently, this study was developed under the assumption that apprentices exposed to annotated pictures will learn to explore images more thoroughly and pay greater attention to the annotated areas compared to control participants exposed to the same images without any annotation, thereby producing a richer verbal description of the same pictures.

Therefore, we hypothesize that:

- H1) the fixation durations will be longer (more attention allocated) in specific areas of the shirt but shorter in irrelevant and non-annotated parts of the image in the group exposed to annotations (experimental) compared to a group not profiting from annotation (control) during the treatment;
- H2) the fixation durations in relevant areas will be longer after the treatment compared to the control group in the different areas of the shirt;

– H3) the gaze coverage of the image will be larger in the experimental than in the control group;
– H4) the experimental group will be able to produce a significantly higher number of details in the verbalized description of the images after the intervention.

Methods

Sample

The sample comprises 38 apprentices randomly assigned into two groups, 20 for the experimental *(Mage = 16.8, SDage = 1.21, all females)* and 18 for the control group *(Mage = 17.56, SDage = 3.83, all females*). The apprentices were enrolled at the beginning of the second year of their three-year certificate program and were recruited from two vocational schools in Switzerland, which provides a well-established fashion design curriculum.

Original Task and Design of the Experiment

Activities that rely on visual expertise are part of the daily practice of apprentices and teachers provide students with opportunities to train this skill. For this reason, we took inspiration for the design of our experiment from a didactical scenario that students perform weekly in their course since the first year in which focus on a wide range of skirts and trousers, then on shirts in the second year and coats and more complex garments in the third. This task is interesting 1) for the manner in which teachers use annotations to direct a student's attention and 2) for the request to analyse the garment. In this exercise, students have to observe the image 'Fig. 1' (left) and provide a full description comprising possible measurements and number and type of parts that compose a garment. Thereafter, the teachers provide the same image with annotations such as lines and arrows or colours and text and initiate a conversation with the students that reviews the entire image 'Fig. 1' (right).

Stimuli and Annotations

Stimuli were selected with the help of the teachers who identified 20 photographs depicting shirts with a range of peculiarities related to shapes, style, details, and parts. These images were then distributed in four subsets of five images each, to be used for the pre-test (5 images), training 1 (5 images), training 2 (5 images), and post-test (5 images). The distribution was made by the teachers in order to make the four subsets equal with respect to their general complexity. Teachers also provided detailed descriptions of each image, highlighting the relevant areas of the garment such as sleeves, stitching, pockets, neck, cuffs, hem, buttons, and the opening (an open section at the top of a garment for the neck of the wearer). These are areas of high relevance and are the ones on which annotations were positioned in the training sessions of the experiment. Annotations took the form of circles, squares, and

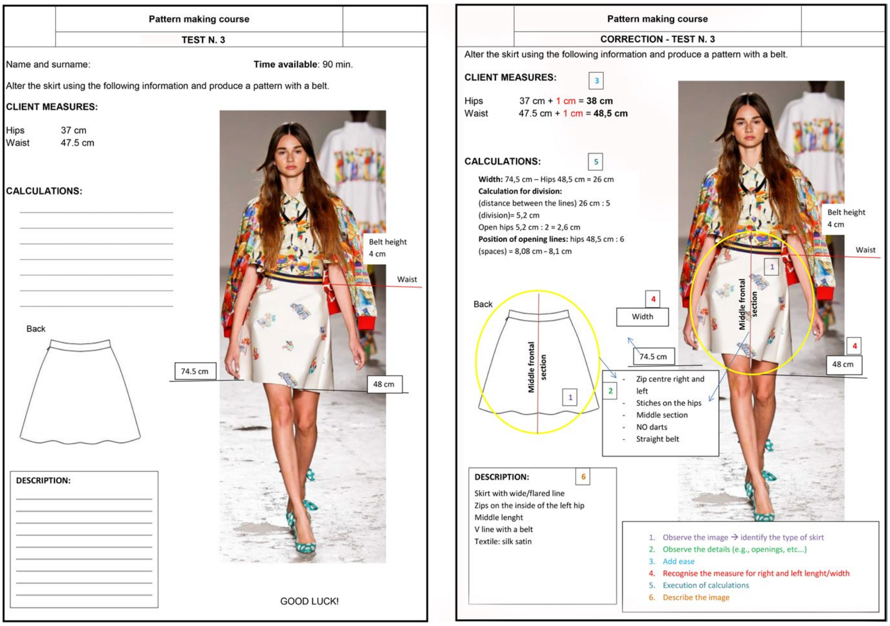

Fig. 1 Examples of the activity before completion (left) and corrected by the teacher (right)

rectangles and these specific shapes were selected to redirect students' attention to defined and specific areas and keep their gaze within those delimited sections while distinguishing and highlighting features present in adjacent areas ('Fig. 2'). Moreover, the position of the annotations was determined not only to highlight

Fig. 2 Annotations placement: non-annotated (pre-test and post-test, left) and annotated image (training 1 and 2 for the experimental group, centre and right)

the corresponding areas but to foster a systematic and comprehensive way to observe the images

Apparatus

The Tobii Pro X2-60 Eye tracker was used to collect the students' eye movement. The tracker is able to sample data binocularly at 60 Hz. The tracker holds a gaze accuracy of 0.4° (binocular and monocular), gaze precision of 0.34° (monocular) and 0.45°(binocular). Gaze measures were classified with the default setting of Tobii Pro Lab (velocity-based algorithm: peak velocity 30°/s, min. fixation duration 60 ms). Stimuli were presented via the Tobii Pro software (Version 3.4.8) connected to an HP laptop and a 15-inch PC screen (HP ZR2440w) with the maximum resolution of 1920 × 1200 pixels. The eye tracker, screen, and laptop were placed on an ergonomic table that could be adjusted by height. Also, a chair with resting arms was placed at the recommended distance (65 cm) in front of the table and both the seat and table were placed at an appropriate height to capture the gaze of each participant. A head stabilisation system was not required.

Procedure

Before the beginning of the sessions, the researchers set up all the tools and adjusted the room: tables and chairs were positioned, the brightness from the windows was adjusted using blinders, and the positions of the chair, table, and computer screen were marked with tape. Afterwards, participants were welcomed in the room only one at a time and were asked to find the most comfortable position on the chair. Basic information about the experiment and the functioning of the eye tracker was provided, and the participants were instructed to avoid movements such as tilting or turning the head, looking away from the screen or at the researcher, and obstructing the eye tracker in any way. Then, the experimenter initialised the 9-point calibration procedure. Due to time constraints imposed by the school and the length of the

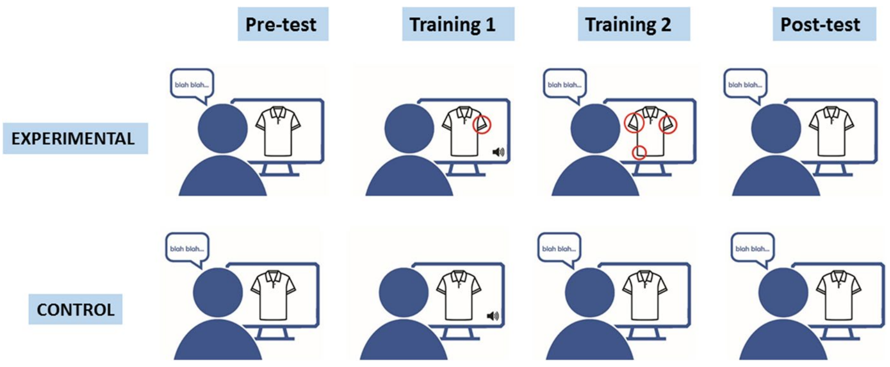

Fig. 3 Schematized presentation of the procedure with the two groups

design, calibration was repeated only in case of loss of connection between the PC and the eye tracker.

The specific procedure of the experiment was performed in the following manner (see Fig. 3): in the pre-test, each participant (experimental and control) was exposed to a set of five images depicting garments displayed on a PC. Each picture was displayed for 40 s (plus 20 s of a black screen before the next image), during which the participants were asked to verbally describe (concurrent think-aloud) the garment.

In training 1, participants of the experimental group were asked to look at a series of five images for a total of 03.27 min; each of them was completed with visual annotations and an audio description inserted by the teacher. The visual annotations entered progressively alongside the related piece of the audio description and then faded out in a manner in which only one annotation was present on the screen at the same time. Participants in the control group were asked to look at the same set of images, but no visual annotations were provided to them.

In training 2, the experimental group was presented with another set of five images and asked to observe each of them and to describe it verbally (each image was displayed for 40 s each, followed by 20 s of a black screen before the next image). Each image was annotated, but in contrast to training 1, the annotations were present on the image for the entire duration of 40 s. In contrast, the control group was exposed to the same set of images, but without any annotations, and was similarly asked to describe them verbally.

In the post-test, all the participants (experimental and control) were asked to observe a new set of 5 images for 40 s each (plus 20 s of a black screen before the next image) and to provide a verbal description as they had done in the *pre-test* phase. No annotation was present in this case. Each image was initialised manually by the experimenter after warning the participant that a new image was going to be displayed.

The whole procedure lasted about 30 min: although one could assume that these kinds of intervention might need more time to be effective, we had to limit the duration of the intervention to make it feasible for the apprentices and the school.

Measures

Fixation durations: this measure comprises the duration of fixations on each of the images presented in pre-test, training 1, training 2 and post-test.

Gaze coverage: a metric used in the area of eye tracking but defined in different ways (see Holmqvist et al., 2011; Van der Gijp et al., 2017). Coverage has been used in a limited number of studies that pointed out that experts and novices differ in the amount to which they observe images or videos (e.g., Jaarsma et al., 2014). In our case it was defined as *"the proportion of the image which is gazed at by the individual at least once. The measure was computed by retrieving the heatmaps for each given image, estimated over the duration of the stimuli. Then, we thresholded the heatmaps based on a fixed value and computed the gaze coverage as the ratio of pixels which were above the threshold over the total amount of pixels in the image.*

In our experiments, the threshold was set to 0.005, given that the heatmap values were normalised so that the maximum value was 1" (see Oertel et al., 2019, p. 390).

Verbalisation score (concurrent think-aloud): to calculate the score, audio of the participants' verbalisations was extracted and manually transcribed. The score was based on the written professional descriptions of all the images provided by the teachers involved in co-designing the study. A list of 52 features (e.g., opening, neck, bottom, cuff, hem, pockets, ribbon, fit, ruffles, stitching, seam, etc.) were derived and these served as our coding scheme. Participants' scores were calculated by giving 1 to each detail correctly mentioned (i.e., present in the participant's description and in the teacher's description) and 0 to any missing or incorrectly mentioned detail. Since the number of details included was not the same for each image (they ranged from 8 to 17), a weighted score was calculated for each image and then an average weighted score was calculated per group for the different phases of the test.

Areas of Interest (AOIs) for Fixation Duration Analyses

To be able to work with fixation durations it is necessary to connect the eye tracking data with the visual stimuli by using AOIs that, in our case, were manually drawn directly in Tobii Pro Studio. The AOIs have a semantic composition defined by the

Fig. 4 Example of pre-test and post-test AOIs (left) and with the AOIs (right): 'Sleeve' (polka dot), 'Central' (black), 'Neck' (grey and white stripes) and 'Details' (black and white stripes)

experts (see Holmqvist et al., 2011) and in pre and post-test (Fig. 4) AOIs were placed on the section of the shirt (central, neck, sleeve and details) deemed most relevant for the profession in a specific garment since they are observed to understand how the garment is constructed and then how to produce a correct pattern needed for assembling the final garment. These areas are:

- the 'central' part of the shirt is observed to identify the position and type of opening, which characterizes most a shirt; it can also contain cuts, ruffles or folds, pockets and more. Also, this section can dictate the desired fit of the shirt;
- the 'neck' is looked at to understand the type and the connection to the opening of the shirt (for instance V openings connect directly to the neck while openings on the side with a zip often require a completely different pattern);
- the 'sleeves' are important to observe to understand where the central section can be connected (sewed) to the shoulder, to identify the type of sleeve, shoulder features, the type and closure of the cuff (as well as related details) and the desired fit;
- the 'details' include embellishments positioned on different areas of the shirt such as ribbons, embroideries, piping (passepoil)—but also stitching or buttons that can be used for merely aesthetic reasons. Details can influence the pattern and their inclusion might require changes in its design.

Fig. 5 Example of OAIs placed on the shirt in training 1 and training 2—The AOIs 'Sleeve' (polka dot), 'Neck' (grey and white stripes), 'Central' (black), 'Details' (black and white stripes) and 'Shirt' (grey)

Conversely, in training 1 and 2, the AOIs (Fig. 5) were placed on the annotations and the non-annotated part of the shirt. Training 1 and training 2 contains the same AOIs of pre and post-test (central, neck, sleeve) with inclusion of the AOI 'Shirt' placed on top of the areas of the shirt where no annotations had been put by the teachers and the absence of the AOI 'Details' for training 1.

These AOIs are also important for contextualising the participants' verbalisations: indeed, they allow to put in relation what the participant has "looked at" and what has actually "seen" in those fixations. The combination of the AOIs data and the verbalisations allows for a more complex understanding of the apprentices' observational experience, helping to connect the perceptual action of observing a specific section with the processes of the working memory allowing understanding of the reasoning and knowledge behind both novices and experts (Jarodzka & Boshuizen, 2017).

Missing Data and Exclusion Criteria

Due to technical issues, gaze data was lost for two participants in the experimental and one in the control group while audio–video was lost for one participant in the control group. Therefore, the analyses on gaze coverage and fixation durations were performed on 35 participants and the verbalisations on 37. No participant was excluded due to eye tracking calibration issues since calibration was repeated until a good signal was reached.

Data Preparation and Analysis for Fixation Durations and Gaze Coverage

The software IBM SPSS 26 was used to carry out all analyses for fixation durations and gaze coverage. General linear mixed effects models (GLMMs) were used to assess differences between the groups in both fixation duration per AOIs and for gaze coverage. GLMMs were used because they can be an effective method of analysis in case of repeated measures analysis of variance or in many other cases such as with unbalanced designs (i.e., with unequal number of participants within each level of a grouping variable), incomplete data (e.g., with missing observations at one or more time points for numerous participants), non-independence among observations (i.e., when the same task is repeatedly administered to each participant; (see Baayen et al., 2008; Judd et al., 2012). The GLMMs for fixation durations and gaze coverage were performed with a design with crossed random effects with nested observations within participants. Fixation durations data was first extracted from Tobi Pro Studio and imported in Excel for cleanup, and then it was transformed from wide to long format in SPSS. The GLMMs for fixation durations were run with condition and test as fixed factors and subjects and AOIs as random factors. Also, a Bonferroni correction was applied to the data. Gaze coverage database was obtained with a script and was also transformed in long format in SPSS were data were analised with condition and test as fixed factor and subjects and gaze coverage as random factors. A Bonferroni correction was applied in this case too.

Results

Fixation Durations

A series of GLMMs were conducted to identify the effects of presence of annotations on fixation durations on the AOIs for training 1 and training 2.

In the AOI 'Central', results showed a significant main effect of condition *[F(1, 33) = 7.649, p < 0.01]* and a significant interaction condition*test *[F(1, 305) = 6.008, p < 0.025]*. Planned post-hoc comparisons of condition indicated a significant difference between the groups *[F(1, 33.00) = 7.649, p < 0.01]* while comparisons of the interaction showed a significant difference between the groups in training 1 *[F(1, 52.508) = 12.829, p < 0.001, d = 0.584]*.

In the AOI 'Sleeve, results showed a significant interaction condition*test *[F(1, 305.000) = 79.621, p < 0.001]*. Planned post-hoc comparisons of the interaction showed a significant difference between the groups in training 1 *[F(1, 89.901) = 41.016, p < 0.001, d = 1.55]* and in training 2 *[F(1, 89.901) = 25.128, p < 0.001, d = 0.589]*.

In the AOI 'Neck', results indicated a significant interaction condition*test *[F(1, 305) = 3.604, p = 0.05]*. Planned post-hoc comparisons of the interaction indicated a significant difference between the groups in training 1 *[F(1, 59.610) = 4.197, p < 0.05, d = 0.329]*.

In the AOI 'Shirt' (non-annotated part of the shirt), results showed a significant main effect of test *[F(1, 8.000) = 6.349, p < 0.05]* and a significant interaction condition*test *[F(1, 305) = 6.196, p < 0.025]*. Planned post-hoc comparisons of test indicated a significant difference between the trainings *[F(1, 8.001) = 6.349, p < 0.05]* while comparisons of the interaction showed a significant difference between the groups in training 2 *[F(1, 46.884) = 3.979, p = 0.05, d = 0.478]*.

No difference was identified in the AOI 'Details' in both training 1 and training 2.

Further, other GLMMs were conducted to identify the effects of presence of annotations on fixation durations on the AOIs for the pre and post-test.

In the AOI 'Central', results showed a significant interaction condition*test *[F(1, 305) = 6.321, p < 0.025]*. Planned post-hoc comparisons of the interaction indicated a significant difference between the groups at post-test *[F(1, 53.497) = 5.231, p < 0.05, d = 0.579]*. However, results in the others AOIs 'Neck', 'Sleeve' and 'Details' showed no difference between the experimental and control group.

All means and standard deviations are available in the table below (Table 1).

Gaze Coverage

A GLMM was conducted to compare the effect of presence of annotations on gaze coverage. Results showed that the interaction between condition and gaze coverage is not significant *[F(1, 236.091) = 3.747, p = 0.05]*. Planned post-hoc comparisons indicated a significant difference *[F(1, 48.289) = 4.510, p < 0.05, d = 0.451]* between the experimental and control groups at the post-test. The mean values indicate that

Table 1 Means and standard deviations (SDs) of the groups on all tests

	Pre-test		**Training 1**		**Training 2**		**Post-test**	
	M(*SD*)	*M*(*SD*)	*M*(*SD*)	*M*(*SD*)	*M*(*SD*)	*M*(*SD*)	*M*(*SD*)	*M*(*SD*)
	EXP	CON	EXP	CON	EXP	CON	EXP	CON
Central	3.90 (1.56)	3.92 (1.58)	2.62 (1.53)	1.84 (1.12)	1.55 (1.06)	1.26 (0.82)	3.72 (1.62)	3.13 (1.26)
Neck	5.77 (3.71)	6.12 (4.00)	2.14 (1.70)	1.63 (1.37)	3.11 (1.53)	3.08 (1.81)	3.54 (2.31)	3.77 (2.61)
Sleeve	1.20 (0.630)	1.19 (0.694)	1.75 (1.09)	0.723 (0.610)	1.09 (1.21)	1.90 (1.53)	1.34 (0.734)	1.28 (0.726)
Details	1.43 (1.71)	1.46 (1.75)	-	-	2.38 (1.77)	2.19 (1.79)	2.03 (2.43)	1.81 (1.93)
Shirt	-	-	18.14 (7.13)	18.13 (6.98)	11.56 (4.95)	13.98 (5.17)	-	-

in post-test, the experimental covered a larger portion of the image compared to control (*respectively* $M_{exp} = 10.95$, $SD = 0.287$ *vs* $M_{con} = 10.82$, $SD = 0.289$).

Verbalisations

To identify a possible difference between the groups, a repeated-measure ANOVA was conducted to compare the effects of condition on the verbalisation score (number of enunciated details) in both the pre-test and post-test. The results revealed a significant main effect of verbalisation score [$F(1, 35) = 7.681$, $p < 0.01$, $\eta_G^2 = 0.769$]. However, the between-subject effect was not significant, $F(1, 35) = 3.423$, $p > 0.05$, $\eta_G^2 = 0.436$] as well as the interaction [$F(1, 35) = 0.640$, $p > 0.05$, $\eta_G^2 = 0.122$] (Fig. 6).

Discussion

Are There Significant Differences in Terms of Fixation Duration Between the Groups?

Our main hypothesis was that the experimental group would look longer at the annotated AOIs ('Neck', 'Central', 'Sleeve', and 'Details') and less at non-annotated areas ('Shirt') compared to the control group. Also, that at post-test the experimental group would look longer at the relevant areas of the shirt compared to the control group. Results of training 1 indicated that the experimental group looked longer at the AOIs

Fig. 6 Number of details mentioned by the experimental and control groups in the pre-test and post-test

'Central', 'Neck' and 'Sleeve' but no significant difference between groups was found for AOI 'Shirt'(while the AOI 'Details' was not present). Conversely, in training 2 the experimental group fixated significantly less than control in the AOI 'Shirt' and no difference was found in other AOIs beside 'Sleeve' where the control group looked longer. Further, results of the pre and post-test pointed out that the experimental group looked significantly longer in the AOI 'Central' than control. However, the other AOIs showed no significant difference between the groups.

Therefore, our hypothesis can be confirmed in the AOIs 'Central', 'Neck' and 'Sleeve' of training 1, 'Shirt' of training 2 and the AOI 'Central' of the post-test. However, these results indicate that the impact of annotations was limited to when present on screen in the training session and that, in their absence, the experimental group looked longer than control only in one AOIs at post-test. Also, if training 1 seems to have affected the apprentices' gaze as expected that was not true for training 2 where, beside 'Shirt', no difference was found in the AOIs for the experimental group. This partially unexpected result might be traceable to the modality effect (Glenberg et al., 1989). This effect indicate that cueing performed with both visual and audio is more effective than cueing that uses only one of the two channels (see Mayer, 2002). In this case, cueing in training 1 was performed with annotations appearing one after another while matched by an audio description of each of the annotated area, while training 2 had no audio and annotations were presented all at the same time for the duration of the image on screen (40 s). Training 1 potentially induced the apprentices of the experimental group to focus only on the annotated areas present on screen in that moment and ignore the rest; while in training 2 they had more freedom to observe the different sections of the image as well as the control group who viewed a non-annotated image for the 40 s. Although these mixed results, annotations seem to still have an effect on the experimental group that observed significantly less non-annotated part of the shirt (AOI 'Shirt').

Are There Significant Differences in Terms of Gaze Coverage Between the Groups?

We expected the experimental group to have achieved at post-test a larger coverage of the image since annotations were placed in all the most relevant parts of the shirts to train the apprentices to observe certain areas but also to observe the garment in its totality. But a non-significant—merely statistically significant—difference was found between the two groups even if the experimental group covered a larger portion of the image at post-test compared to control group. This result indicates that annotations did not have the desired effect in attracting participants' attention to specific areas but not across the whole image. However, this result is not completely out of the ordinary since fostering coverage of images can be a complex task and sometimes, after interventions, the increased coverage is limited (see Eder et al., 2020).

Are There Significant Differences in Terms of the Verbalisation Score Between the Groups?

In contrast to expectations, it was found that the experimental group did not mention more details than the control group (even if in the post-test, there was an increase in their verbalisation score). Moreover, students were able to describe a high number of details even at pre-test, and this especially true for the control group; this might have caused the training to not be as impactful as expected. Further, the request to verbalise could also have influenced participants' gaze since concurrent think-aloud can affect the manner in which participants look at visual materials (e.g. Hertzum et al., 2009; Oh et al., 2013). Further, verbalisations were added to the study as a second measure for expertise and were introduced since the teachers indicated that students are required to describe images while they perform class activities.

Conclusions

In summary, our results indicate that annotations attract students' gaze in most of the AOIs in training 1 but in just one at post-test and training 2. Also, annotations did not affect the apprentice's gaze coverage or verbalisations as strongly as expected.

We should note some limitations that could have influenced the results. For instance, the task and stimuli were selected in agreement with the teachers to create an ecological task and to be profession-specific, as suggested by Jarodzka et al. (2017); however, the images might have been too simple to identify a huge difference between the two groups compared to images such as radiographies or technical drawings. Also, results from the training sessions indicate that the format of training 1 is more effective in attracting the gaze of the apprentices since visual annotations are presented one after another and paired with audio description of the garment, a strategy that has been proved useful in many studies (see Mayer, 2002). This could be exploited even further by positioning an high number of annotations on the images to recreate an 'ideal trajectory' for the participants or, alternatively, use model's eye movements to show participants the best way, according to the expert, to explore the images (see, Jarodzka et al., 2013). Further, concurrent think-aloud during pre and post-test and training 2 could have had contrasting impact with the annotations and, therefore, retrospective think-aloud should be considered as an option in future studies on cueing. Another potential limitation is the length of the two training sessions that amounted to only few minutes; a longer session or multiple sessions repeated during weeks or months could have led to better results; however, students were at the beginning of their second year and they would have started lessons on shirts very soon, thereby impacting the ecology of the study. It is possible that second-year students might be already familiar with the task (already trained in the first year although on different kind of garments, in particular skirts) to actually benefit from the training and that it might be more valuable for younger students.

Despite its limitations, this study participates in the discussion of numerous questions in vocational education. For instance, it constitutes one of the few examples exploring the initial training of fashion designers. It also contributes to the small but fundamental literature on visual expertise among fashion designers and strengthens its importance in the profession; being exposed to experts' way of looking at a garment by examining their annotations seems a promising technique to improve students' visual skills at work. Finally, the study is ecological and education-based since it builds on a task that is already used in class to teach students how to observe garments with the use of annotations.

Findings could be valuable for teachers to create further learning scenarios (Cattaneo et al., 2015) and implement new tasks to convey a systematic and professional-specific way to observe garments in photos, patterns, and material forms using annotations. For instance, teachers could use annotations in a wide range of tasks in which they show students multiple photos of different parts of the same garment to increase their understanding of the whole item, or while teaching them how to read and create patterns or potentially apply them to video showing manufacturing procedures and tasks.

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Fostering Apprentice Beauticians' Visual Expertise Through Annotations: A Design Experiment Using the Platform Realto

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Abstract

Professional beauticians regularly perform skin analyses and should be skilled at observing small skin anomalies and skin damages. However, little is done directly for improving their observation skills at school, during their training. In order to foster apprentices' observation skills of skin anomalies, a new training scheme exploiting annotations and attention-guiding methods through the use of the platform Realto was developed and tested.

A second year class of apprentice beauticians (N=9) was given a pre-test on the visual expertise of skin anomalies. Then, for a semester they attended multiple training sessions where firstly teachers explained skin anomaly images with the help of annotations (attention-guiding) and secondly, students were asked to observe other images of the same anomalies, annotate them, and then provide a textual description of the identified anomaly.

At the end of the semester, the trained class completed a post-test and a questionnaire, and group interview have been collected. Another group of apprentices (N=19) of the third year who already completed the skin anomaly course was used as baseline. Results showed that the group who participated in the treatment mentioned almost double the amount of details noticed by the baseline group in the post-test; being trained using annotations and the Realto platform proved effective in developing observation skills, compared to normal lessons. Furthermore, apprentices confirmed, both through the questionnaire and the interviews, that they considered annotations useful for improving their observation skills and that using Realto and its annotation facilities was a good way to achieve this result.

Keywords: vocational education and training; annotation; visual expertise skill; cueing; technology-enhanced learning environment

1. Introduction

Visual expertise skills are essential in many occupations, such as engineering (e.g., Katsioloudis & Stefaniak, 2018), medicine (e.g., Naghshineh et al., 2008), architecture (e.g., Styhre & Gluch, 2009) and sports (e.g., Kredel et al., 2017). However, most studies tend to focus on white-collar professions, neglecting the world of vocational education.

This gap in the research is puzzling because vocations strongly rely on visual skills to perform profession-specific tasks. For instance, to create proper clothing, fashion designers must visually explore images of garments to identify details and defects while while keeping specific characteristics of the customer's body in mind (Caruso et al., 2019). Similarly, beauticians must observe the skin of their clients to identify anomalies, provide treatment or offer a cosmetic procedure. This must be done to ensure that a treatment (e.g., pedicure) does not result in injuries and to identify anomalies that require direct medical inspection (e.g., moles with irregular edges or dark black or irritated moles) before any cosmetic procedure (State Secretariat for Education, Research and Innovation, 2007). This is a complex task because various skin anomalies can look similar to each other, which can lead to a diagnostic error and the wrong treatment choice, ultimately leading to potential skin damage.

The current study investigates how to promote observation skills in beauticians' training, with the main goal of fostering visual expertise in observing skin anomalies in apprentice beauticians and increasing their accuracy rate by using a variety of methods (e.g., repeated exposure to annotation of anomaly images).

In the following section, literature on visual expertise-particularly in the dermatological area-will be explored. This line of literature is explored because of the similar knowledge that beauticians and dermatologists share when it comes to skin anomalies. Following this, the literature on methods to foster visual expertise skills will be explored and discussed.

1.1 Visual Expertise Skills in Dermatological Areas

Visual expertise requires individuals to enact different types of processes. The perceptual processes underlying visual expertise are fundamental because professionals cannot only rely on procedural and declarative knowledge (Kellman & Krasne, 2018) to perform their tasks. These processes can be divided into the following four stages: 1) identification of things that are worthy of further analysis, 2) recognition of relevant sections of images, 3) identification of target sections (e.g., lesions) and 4) diagnosis (Waite et al., 2019). For example, perceptual learning allows professional radiologists to perform visual searches in X-rays and process information to interpret lesions (Ravesloot et al., 2012), as well as recognise patterns of symmetry, colours and shapes (Shapiro et al., 2006). It also helps artists shift between the local and global processing (Chamberlain & Wagemans, 2015) of images.

Much like beauticians, dermatologists perform tasks such as skin analyses and visual recognition of skin conditions or abnormalities using two approaches. The first system is perceptual and involves the automatic gathering of information, which includes fast and intuitive thinking, pattern recognition and the use of heuristics. The second system is slow, logical, analytical and, most of all, deliberate and conscious. With the first system, dermatologists can 1) recognise anomalies, even if they only see a part of them (e.g., unilateral and clustered symptoms), 2) group objects that are close to each other (e.g., simultaneous presence of telangiectasia, papules, macules and hypopigmented area being a manifestation of Goltz syndrome), 3) identify anomalies by a specific colour (e.g., erythema can vary from light pink to red) and 4) separate healthy from unhealthy skin (e.g., figure separation). Other perceptual elements involved in the first system that can help in identifying lesions are 1) the pattern or silhouette of the outline of the lesion, 2) location since lesions tend to appear only in specific areas and 3) contextual information (e.g., age and gender) (Lowenstein et al., 2019). The second system uses high-level processing, which is characterised by mnemonics, algorithms, a checklist and a list of diagnoses (Ko et al., 2019).

1.2 Improving and Supporting Visual Expertise Skills in Novices

Improving one's visual expertise is not a new topic and has been explored using different approaches. For instance, the signalling approach is based on the principle postulated by Mayer (2005), which indicates that any kind of signals, such as arrows, colours or text, applied to presented content will help learners diminish their cognitive load while also identifying the relevant targets among the irrelevant ones much faster than without any cues. These signals or annotations can assume different forms, such as colours, text, gestures, flashlights (Schneider et al., 2018), transparent overlay, graphic organisers, shapes and diagrammatic elements (Heiser & Tversky, 2006), which include free lines (Shin & Park 2019; van Gog, 2014), among others. These types of annotations are used by researchers to investigate how to train novices to observe images by directing their gaze and their attention towards the task-relevant and salient parts of content.

For example, in educational contexts, arrows have been shown to be effective when applied to animations (Boucheix & Lowe, 2010) or colour patches on sports videos for training (D'Innocenzo et al., 2016). Annotations such as circles, colours and highlights have been used effectively on textual content (Stefanut & Gorgan, 2008; Zywica & Gomez, 2008). Annotations such as colour shading and circles on X-rays have also proved useful to highlight important elements of fractures (De Koning et al., 2007; Scheiter et al., 2019).

The use of annotations to foster visual expertise in the dermatological area is limited compared with other medical fields (e.g., radiology), but not untraceable. One example is the work of Friedman et al. (1985), who developed a list of criteria (e.g., asymmetry, colour, colour uniformity, border regularity and texture) to diagnose anomalies. This list was used in a study where novices viewed 45 images of anomalies with the help of a sheet (Figure 1) that contained diagnosis criteria, a small drawing and a continuum bar indicating the range of possible presentations of that criteria (e.g., uniform to nonuniform, light to dark, small to large, symmetric to asymmetric, regular to irregular and smooth to rough). These anchors did not have a considerable impact on the diagnostic scores, but the study sample was very small (Zanotto et al., 2011).

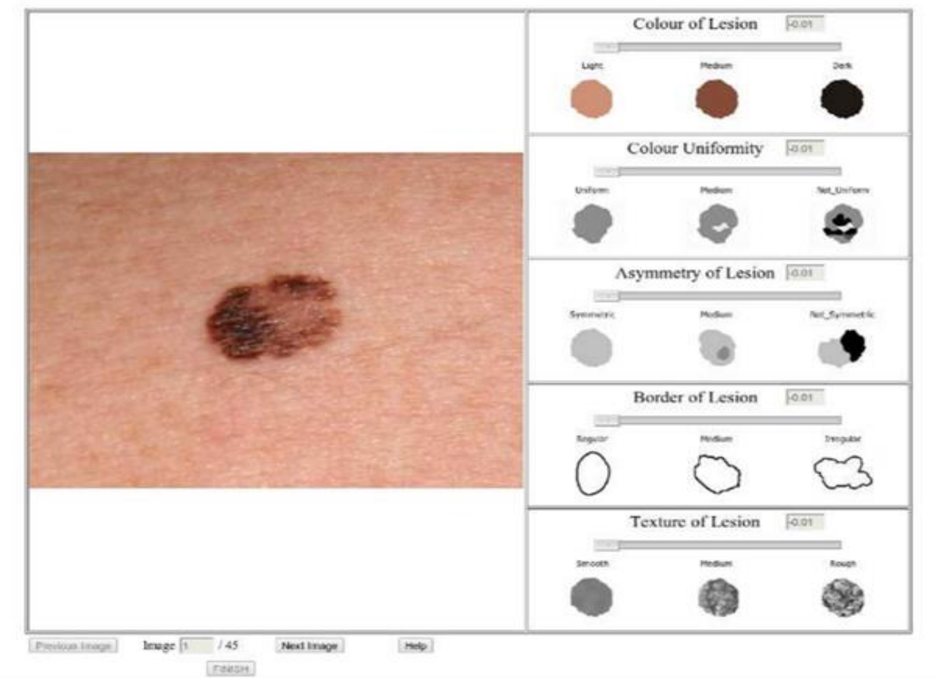

Figure 1. Example of anomaly images and anchors created by Zanotto et al., 2011

Other studies have focused on developing electronic tools to ease the work of professional dermatologists. One example is a tool containing manual segmentation, labelling and image manipulation functions (Ferreira et al., 2012). As a comprehensive tool, LesionMap contains the functions needed to indicate information about anomalies, such as orientation, width, position and opacity (Figure 2; Eapen et al., 2020).

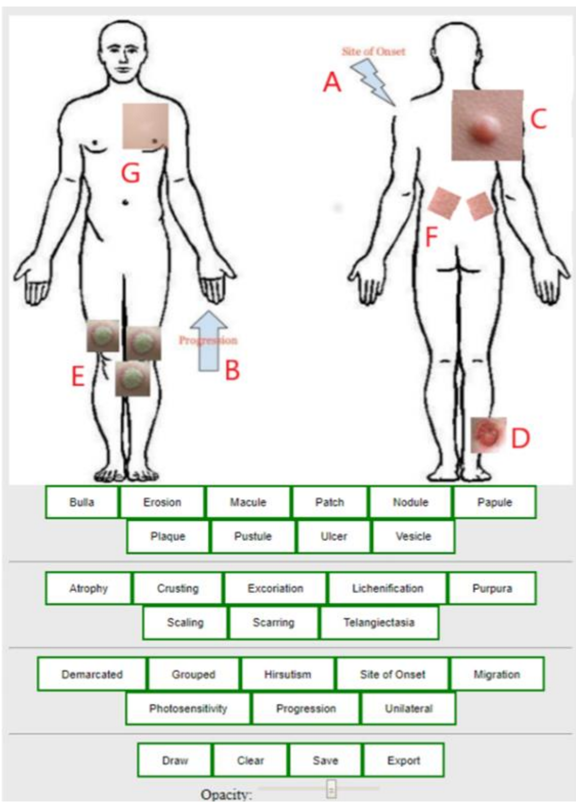

Figure 2. LesionMap developed by Eapen et al., 2012

How to train novices to develop their visual expertise skills, however, is still a question worth investigating. For instance, Dolev et al. (2011) developed eDerm, a curriculum for dermatologists that successfully increased diagnostic rates. eDerm contains 17 tutorials and lectures on pigmented and nonpigmented lesions, melanoma, nonmelanon skin cancer, nevi and other benign dermatoses. Other studies have used a memory approach and asked complete novices to match images of anomalies (e.g., basal cell carcinoma, squamous cell carcinoma and seborrheic keratoses) to different sets of images of anomalies (Brown et al., 2009). Similarly, the applied behaviour analysis, precision and training method has been shown to work with a memory approach, based on students who were asked to go through flash cards depicting images of skin anomalies on one side and the names of the anomalies on the other side. This method has proven useful in the recognition of anomalies compared with normal training methods (McGrath et al., 2018). Likewise, perceptual and adaptive learning modules (PALMs) train students by exposing them to digital flashcards containing images of anomalies. Students are shown the images and presented with four possible answers and feedback. The algorithm of PALMs dynamically adjusts the presentation of the images and increases the accuracy of the trainees (Rimoin et al., 2015).

Further, a completely different way to train dermatologists is with art, such as paintings. In fact, with visual thinking strategies, students are trained in general observation through the use of paintings and discussion on topics, such as the meaning of visual expertise and the relationships between observation and communication as well as ambiguity and subjectivity. Evaluations of this method indicate that students' diagnosis and image description skills improved (Zimmermann et al., 2016). Another example of the use of art is seen in the study by Kyriakou and Kyriakou (2021); using Frida Kahlo's paintings, the authors presented examples of dermatological issues that affected the painter to train novices in recognising skin anomalies.

The literature reviewed until this point has indicated a gap in existing studies on enhancing visual expertise in a non-medical field, especially in vocational professions. This gap can be filled by taking advantage of the unexplored potential and richness of vocational professions relying on visual expertise. Therefore, the present study will focus on fostering apprentice beauticians' observation of skin anomalies by using a training method that combines annotations and written descriptions. This method is based on the literature presented above from the dermatological field.

1.3 Hypotheses

Our hypotheses are that students exposed to 1) the use of annotations (teacher-driven annotations, as well as the student's own annotations) to pinpoint skin anomalies and 2) making their own textual descriptions of images of skin anomalies will:

- H1) write more detailed descriptions of skin anomalies at the post-test stage compared with the pre-test stage, after being presented with the images of such anomalies.
- H2) write more detailed descriptions of the images of skin anomalies at the post-test stage than those who completed a traditional course on skin anomalies.
- H3) positively rate the impact and usefulness of annotations and descriptions on visual expertise.
- H4) rate the experience with Realto, specifically its annotation tool, as positive.

2. Method

2.1 Sample

The discussion guide focused on expanding and deepening the topics already faced in the questionnaire and investigating in detail the apprentices' and teachers' experiences with both the activities and platform. The three macro-categories identified for the interviews were: a) the relevance of visual expertise in the profession, b) the perceived usefulness of annotations and descriptions in helping observations and c) the sample experience with the platform and its potential additional uses for the future.

The interviews with the learners lasted 49 minutes on average (min = 43 min; max = 55 min), while the individual interviews with the teachers lasted 39 min on average (min = 35 min; max = 43 min). The interviews were conducted and recorded via the Zoom videoconferencing software. A content analysis (Miles & Huberman 1994) using NVivo was applied to the whole corpus. This process involved three steps: first, the interview data were transcribed verbatim; second, the most salient themes were identified, according to the macro-categories; third, the themes were further coded to create micro-thematic categories.

2.2 Outline of the Study

In January 2020, the experimental and baseline groups were exposed to the same pre-test on the recognition of elements present in skin anomaly images. From February 2020 to June 2020, only the experimental group attended the annotation and description training using the platform Realto via the videoconferencing software Zoom. In June 2020, the experimental group was exposed to a post-test (identical to the pre-test). Further, the experimental group was asked to answer a questionnaire on their perceptions of the usefulness of using annotations and descriptions to foster visual expertise, as well as their experience with the annotation tool of Realto. Finally, the experimental group was asked to take part in a discussion on their experience with visual expertise in the profession, the use of annotations and descriptions, and their general experience with the platform Realto.

2.3 Materials

2.3.1 Pre-Test and Post-Test

All materials were cocreated with the teachers, including the pre-test, post-test and training activities. The pre-test and post-test are identical and focused on skin analysis, which is the main topic apprentices must learn about in their second year. In the test, the participants were first asked to observe and provide written descriptions of images depicting different body parts (Figure 3 - left). Then, they were asked to observe and provide written descriptions of images depicting sections of faces (e.g., cheeks, mouth) affected by skin anomalies (Figure 3 - centre). Finally, they were asked to observe and provide written descriptions of images of faces affected by conditions (e.g., young woman, middle-aged man, old woman) (Figure 3 - right). All the sections of the test prompted the apprentices to analyse the skin as professionally as possible, as if they were in front of a real client and performing a skin analysis (or anamnesis).

Figure 3. Arm affected by psoriasis (left), section of a face affected by rosacea (centre) and face of a woman with different sign of aging (right)

The scores of the pre-test and post-test were based on the written professional descriptions of the images provided by the teachers who codesigned the study. The teachers' descriptions of the 11 images contained 103 details (e.g., inflammation, spots, blisters, dilated pores) and covered all skin anomalies present in their school curriculum that beauticians must identify and treat (e.g., dry skin), refer to a doctor (e.g., psoriasis) or, in some cases (e.g., age spots), propose a correction for with make-up (e.g., foundation). Each apprentice's score was calculated by attributing one point to each detail found in their description that was also present in the teachers' descriptions and then summing them. In contrast, any missing or misrecognised detail was attributed zero points.

The pre-test and post-test were created while taking the experience of beauticians in the workplace into consideration as well as the final apprentice exam, when third-year students have to perform a detailed skin analysis of a potential client.

2.3.2 Questionnaires

The questionnaire was composed of items from the Usefulness, Satisfaction & Ease of Use (USE) Questionnaire (Lund, 2001) and other items designed specifically for the current study to measure the perceived usefulness of annotations and their impact on visual expertise as well as the perceived usefulness of description. The participants had to indicate on a five-point Likert scale how much they agreed with the affirmative assertions that were successively proposed.

- The usefulness scale (Cronbach's α = .936) of Lund's (2001) USE questionnaire served to assess the apprentices' perceptions of the usefulness of the annotations (e.g., "Annotations helped me be more effective").
- Two sets of 11 items were designed to measure the impact of annotations on visual expertise. The first 11 items (Cronbach's α = .886) referred to the annotations carried out by the teacher (e.g., "The teacher's annotation helped me identify textures specific to a given anomaly"), while the second 11 items (Cronbach's α = .926) referred to annotations carried out directly by the apprentices (e.g., "My annotations helped me identify textures specific to a given anomaly"). These two sets were inspired by analogous research in the area of visual expertise (see Chamberlain & Wagemans, 2015; Ko et al., 2019; Lowenstein et al., 2019). These items were designed to

facilitate understanding of whether the annotations affected the apprentices' visual expertise on a whole image and its details, the texture of anomalies and tissues, and some details they had not seen in that image before or previously had not considered relevant.

- One set of three items (Cronbach's α = .658) was created to measure the apprentices' perceptions of the usefulness of the descriptions (e.g., to "Integrate the visual information with the theory").

2.3.3 Discussion Guide for the Interviews

The discussion guide focused on expanding and deepening the topics already faced in the questionnaire and investigating in detail the apprentices' and teachers' experiences with both the activities and platform. The three macro-categories identified for the interviews were: a) the relevance of visual expertise in the profession, b) the perceived usefulness of annotations and descriptions in helping observations and c) the sample experience with the platform and its potential additional uses for the future.

The interviews with the learners lasted 49 minutes on average (min = 43 min; max = 55 min), while the individual interviews with the teachers lasted 47 min on average (min = 27 min; max = 40 min). The interviews were conducted and recorded via the Zoom videoconferencing software. A content analysis (Miles & Huberman 1994) using NVivo was applied to the whole corpus. This process involved three steps: first, the interview data were transcribed verbatim; second, the most salient themes were identified, according to the macro-categories; third, the themes were further coded to create micro-thematic categories.

2.3.4 The Realto Platform and its Image Annotation Tool

All activities were performed using the learning platform Realto, which was developed as part of the Dual-T project. The platform was created with the objective of connecting and supporting the experiences that apprentices have in different learning environments, such as school, branch courses and the workplace. Realto's look and feel is similar to a social network, but it contains multiple features created specifically for dual education. Besides features oriented to sharing educational and workplace content with teachers and classmates, the features that are used by teachers and students most often are the activities. Realto offers multiple types of activities, such as multiple-choice questions, textual replies with uploaded files, image annotations and many others. The image annotation, video annotation and textual reply activities are the ones used in this research. Image annotation activities are performed using the annotation tool, an image manipulation function through which users can open an image and apply annotations to it. Users can access the tool by clicking on an image and then pressing the brush icon (Figure 4 - left), which is visible on the central top of the screen. Realto will then display the picture on a black background alongside the annotation tool bar. The annotation tool bar (Figure 4 - right) contains all the typical functions available with other annotation applications (e.g., SketchBook Pro). Users can perform different actions using the tool, such as 1) draw free lines, 2) add shapes (square, arrows and circles), 3) change the colours of shapes, lines and text, 4) select lines, shape or text, 5) add text and change its size and 6) edit the transparency and layers of elements (e.g., overlay).

Figure 4. Annotation brush visible on each image uploaded in Realto (left) and Realto's annotation bar with all its functions (right)

2.3.5 Procedure for the Activities

Each lesson performed with the experimental group followed the procedure described below.

- Teacher-driven annotations: Each lesson began with the teacher uploading images of anomalies on Realto as a post and then sharing the screen with the students via Zoom. Then the teacher clicked on the images and proceeded to explain their relevant details while performing annotations (i.e., teacher-driven annotations), such as coloured marks or circles, to allow students to better understand the specific features of the disease, including differences in colours, variations in textures, and the presence of extraneous tissues or multiple anomalies (Figure 5). The teacher's annotations on the images were performed using the annotation function available for every image uploaded to the platform.

Figure 5. Teacher-driven annotations for dermoscopy images of different anomalies

- Students' annotations and written descriptions: The lesson continued with the teacher launching an activity, and asking the students to open the activity and carry it out in the appropriate section of Realto To view the activities, apprentices had to go to the section of the platform where all the activities created by the teacher are stored. The exercises contained the images related to the topic explained by the teacher in the first part of the lesson. The students were first told to "Observe this anomaly as if it were the skin of the client. Use the annotation functions to signal the anomaly or the anomalies present in the image. Also, try to annotate all the main features present in the image, such as deformations, colours, shapes and textures or other abnormal aspects of the image." After that, the students were asked to "Write a complete description of the image referring to deformations, colours, shapes and textures or any other abnormal aspect of the image." By clicking on the correct activity, the students are able to view the description of the task and the images. Afterwards, apprentices could click on the images and annotate them, and click on the available text box to complete the descriptions.
- Correction of the activities: After all the students had completed the activities, the teacher opened the exercises in the results section of the activities section of the activities and shared her screen. Realto allows teachers to display all the students' annotations overlapped on the same images and check or uncheck (i.e., visualise or not) a single participant's contribution. Apprentices had the chance to look at their own annotations that were performed on each of the images in the exercise as well as those of their classmates. Similarly, the teacher was able to open the textual replies and comment on the results of all the students. During the correction period, the students were invited to ask questions and reflect on the elements that were correctly identified, the ones that were missed, and the work of their classmates (Figure 6).

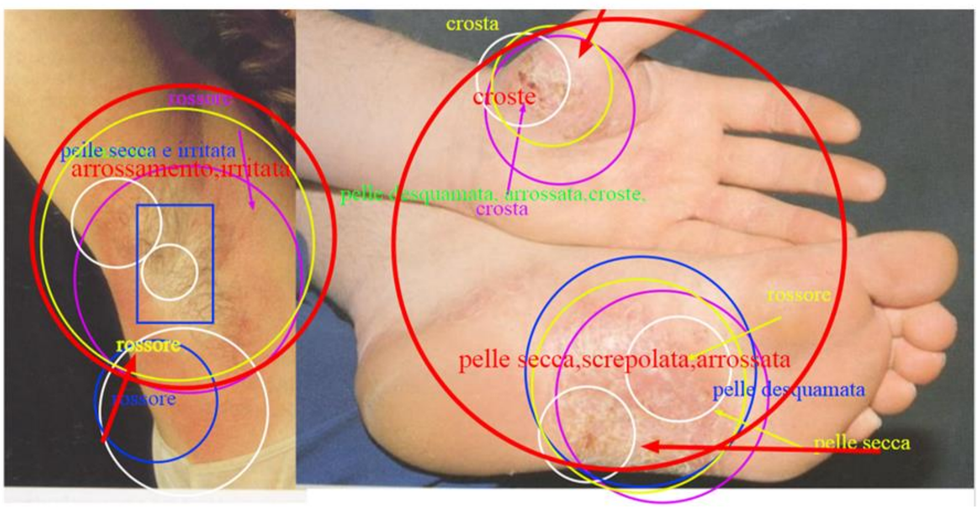

Figure 6. Students' overlapped annotations and the correction of descriptions

3. Results

3.1 Pre-Tests and Post-Tests for the Written Descriptions

A Wilcoxon signed-rank test was run on the pre-test and post-test written description scores of the experimental group. The post-test ranks (Mdn = 28.00, SD = 3.23) were higher than the pre-test ranks (Mdn = 14.00), ($Z = 2.371$, $p = .018$, $\eta2 = .80$). This confirms the direct impact of the activities on the number of details present in the descriptions. Further, a

Mann–Whitney U test was run on the post-test (which was the only one carried out for the baseline group) scores of the experimental and baseline groups. The results indicated that at the post-test stage, the experimental group wrote significantly more details (Mdn = 28.00, SD = 6.14) compared with the baseline group (Mdn = 16.00) ($U = 6.50$, $p = .001$, $\eta 2 = .47$), suggesting a positive impact as a result of the treatment (Figure 7).

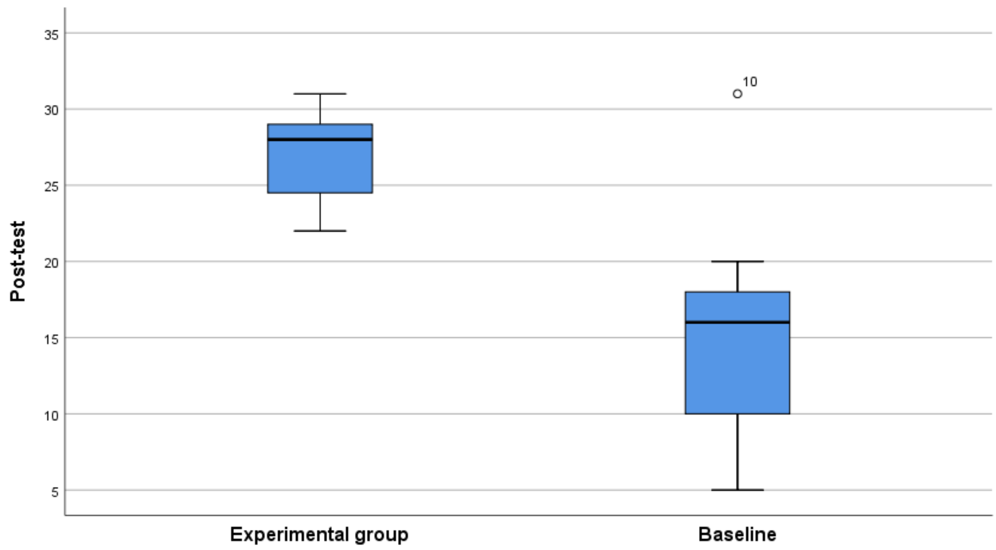

Figure 7. Scores of the experimental and baseline groups at the post-test stage

3.2 Questionnaire

3.2.1 How Useful Do Apprentices Perceive Annotation Tasks to Be?

The participants' replies for the items related to the "Perception of usefulness of annotations" mostly ranged between "agree" and "strongly agree," while a few chose "neither disagree nor agree" or "disagree." The only item that strayed from the rest was "Time-saving," for which some of the participants expressed a slightly more negative outlook, with 44.50% choosing "agree," 22.20% selecting "neither disagree nor agree," and 33.30% selecting "disagree" (Figure 8).

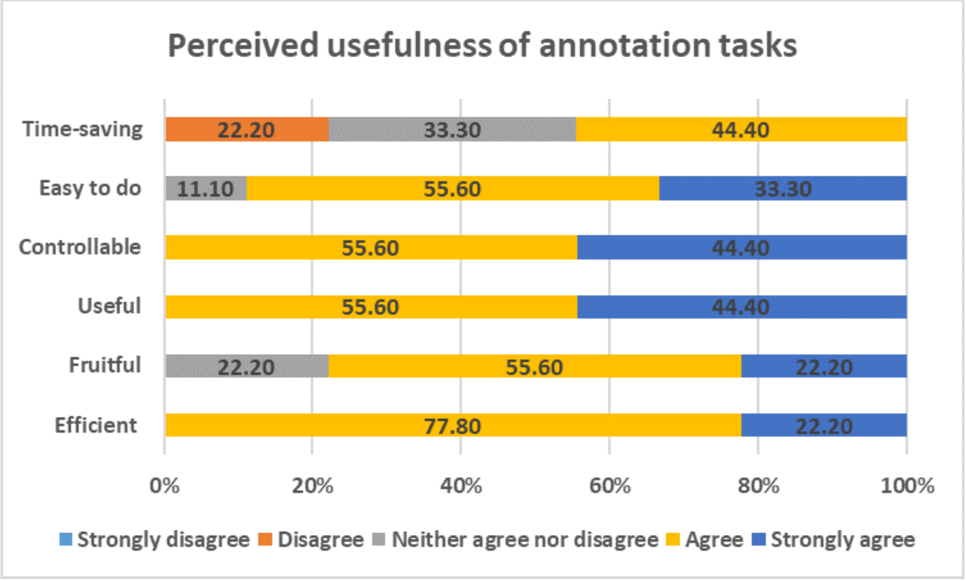

Figure 8. Perceived usefulness of annotation tasks

3.2.2 Do the Apprentices Perceive Annotations As Affecting Their Own Visual Expertise?

A Wilcoxon signed-rank test was run to compare the scores given by the students to their own annotations, as well as the scores given to the teacher's annotations. The results indicate that the students' own annotations ranked significantly higher compared with those of the teachers ($Z = 2.214$, $p = .027$; $\eta^2 = .54$). However, the participants gave both the students' annotations ($Mdn = 4.46$, $SD = .46$) and teacher's annotations ($Mdn = 4.27$, $SD = .37$) high scores falling in the range of "agree." The students perceived their own annotations as affecting their own visual expertise more than the teacher's annotations, although they considered both types of annotations to positively affect their visual expertise (Figure 9).

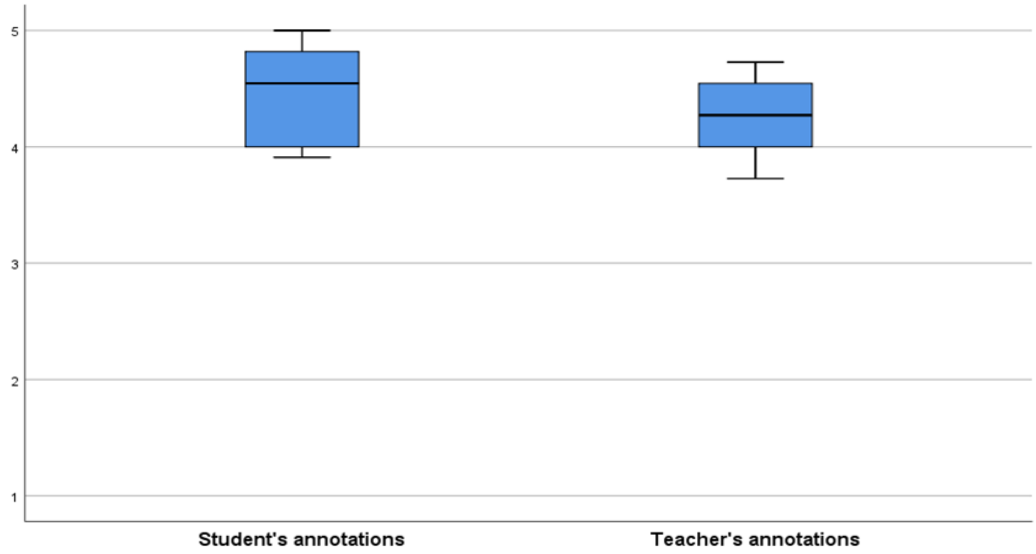

Figure 9. Apprentice's perception of the effect of annotations on visual expertise

3.2.3 How do Apprentices Perceive the Description Activities?

The replies to the question were positive and mostly ranged between "agree" and "strongly agree," with only 11% of replies indicating "neither disagree nor agree" for the item "Helped remembering things." This result implies the importance of descriptions for students because they helped them assimilate the content of the images (Figure 10).

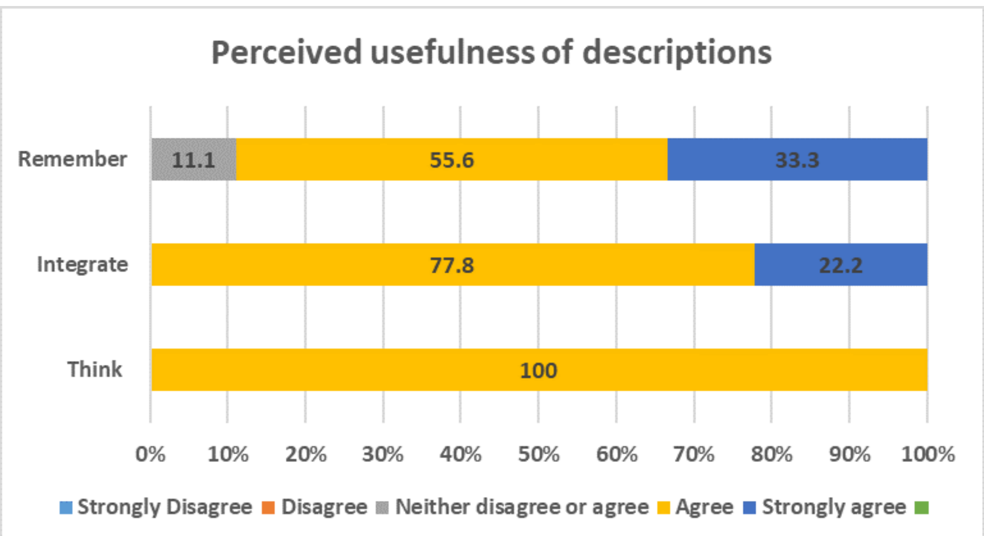

Figure 10. Perceived usefulness of descriptions

3.2.4 How do Apprentices Perceive the USE of the Annotation Tool?

The mean scores of the sample for the four factors of the USE Questionnaire (i.e., usefulness, satisfaction, ease of use and ease of learning) show that the participants gave scores that ranged from "strongly disagree" to either disagree or agree. The factor with the highest score was "usefulness," with a mean of 3.96, while "satisfaction" scored the lowest, with a mean of 3.20 (Figure 11). However, in this case, no score was in a negative range.

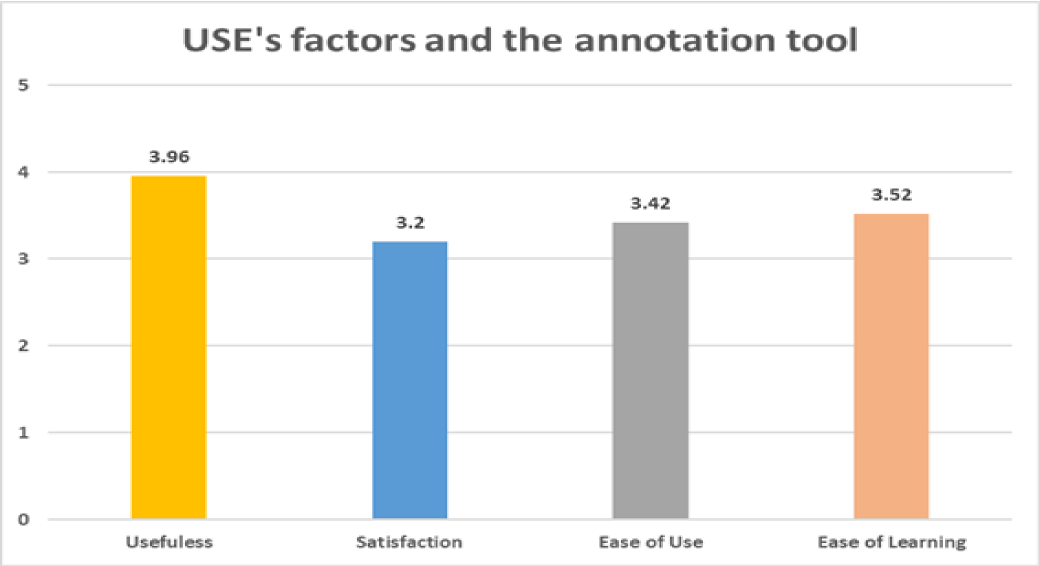

Figure 11. Mean scores for the four USE factors

3.3 Group (Apprentices) and Individual (Teacher) Interviews

3.3.1 Relevance of Visual Expertise in the Profession

The apprentices reported knowing what they should do at work, but indicated that in most cases, they ended up writing down the anomalies and carried on with the treatment (1). However, the teachers explained how to observe, stressing the importance of performing skin analysis as follows (2):

(1) "We should check every inch of the skin and note down the anomalies. But in most cases, we just write down the main things on the folder of the client and we keep it in mind during treatment." (Apprentice_Chiara)

(2) "It's important not to mix up anomalies since they look similar. Before treating the skin, it's important to evaluate its status. We start observing from the top and then we identify the phototype of the skin, shape of the face, type of skin, and skin surface. If I see inflammation on the face, I can't, for instance, colour the eyebrows if the skin is red!" (Teacher_Martina)

3.3.2 Usefulness of the Annotations

The apprentices indicated that performing and seeing annotations during correction is useful. Also, they underlined that a teacher's annotations coupled with an explanation of the anomaly are essential to understand what anomalies look like (3). Further, the teachers reported a positive experience with the annotations as follows, and considered them to have helped apprentices observe, explore and be more attentive (4):

(3) "It is useful. I like the teacher's annotations since she explains the image, like how moles look like and how dangerous they are. Also, she first explains it and then points towards the areas we must look at and evaluate. Without her explanation, I'd not know where to start. I also like seeing my classmates' annotations!" (Apprentice_Francesca)

(4) "Annotations helped with identifying certain elements by 'keeping their eyes peeled.' Annotations impacted visual expertise and students appreciated it and, at the end of the course, they managed to do a proper evaluation of the skin. They can identify the anomalies now since they know which anomalies share similar features." (Teacher_Valentina)

3.3.3 Usefulness of the Descriptions

The descriptions were considered complex to perform (5), but made the apprentices attentive (6) and helped with visual expertise as follows (7):

(5) "Describing images can be complex since I really have to look at the image to be able to describe it properly." (Apprentice_Francesca)

(6) "I've become more focused when I describe images" (Apprentice_Chiara)

(7) "Descriptions were extremely helpful for visual expertise, in addition to annotations. Before we did similar activities on paper, but with Realto, we kept repeating this activity with new anomalies, and it really helped apprentices' visual expertise and identification." (Teacher_Valentina)

3.3.4 Use of Realto in the Future

The apprentices were positive about Realto, but suggested changes in the type of activities to carry out with the platform and more challenging tasks (8). The teachers were also positive and already planned to modify some activities for the next year, as described below (9).

(8) "We should continue with image annotations and descriptions of anomalies of the entire face, but maybe fewer annotations of images with just one big anomaly. It can be too obvious with that." (Apprentice_Chiara)

(9) "Future activities with Realto could continue with the use of descriptions and then also use of visual annotations, but also text annotations. In this case, they don't stop at marking one area, but they already have to name the section of the image and have to connect things." (Teacher_Martina)

4. Discussion and Conclusions

The aim of the current study was to explore the use of annotations to foster visual expertise in apprentice beauticians. The main hypothesis was that the apprentices exposed to teacher-driven annotations, self-managed annotation and description activities would be able to recognise more details in an image analysis task compared with those students trained in the traditional way. To achieve this aim, a group of beauticians apprentices (N=9) of the second-year were firstly exposed to a pre-test on skin anomaly analysis, then to the training sessions for a semester and concluded with a post-test, a questionnaire and the participation to a group interview. Conversely, a class of the third year (N=19), who already completed the traditional course, was used as a baseline group.

The results of the written descriptions from the pre-test and post-test stages showed a significant difference between the groups at the post-test stage, with the experimental group almost doubling the amount of details written by the baseline group. This indicates that teacher-driven annotations combined with the activities 1) positively influenced the apprentices and 2) led them to observe the relevant parts of the image, helping them to recognise and name skin anomalies. Further, the results of the experimental group indicate that a combination of teacher-driven annotations, student-driven annotations and written descriptions of images depicting anomalies were more powerful in training students about skin anomalies when compared with a traditional course. This can be seen by comparing their scores to those of the baseline group; although the baseline group was trained in the regular way during their second year and continued exercising visual expertise during the first part of the third year of their training, they wrote fewer details than the experimental group. It is also important to note that the teacher's descriptions contained a total of 103 written details, a score that is much higher than the students' scores. This confirms the results of other trainings on multiple exposures to anomaly images (e.g., Dolev et al., 2011) and diagnostic accuracy. Future studies in this area could make use of other kinds of signals (e.g., Jarodzka et al., 2013) and include more objective methodologies, such as eye-tracking.

The results of the questionnaires are also positive overall. In the first question about the "Perceived usefulness of annotations," most of the participants considered using annotations as being useful, efficient, controllable, easy to do and fruitful, even if they pointed out that it might not save them a lot of time. Similarly, answers to the items related to the "Impact of teachers' annotations on visual expertise" indicate that the annotations helped the apprentices observe images in their totality and in detail. Almost all participants agreed that the annotations helped them identify specific anomalies, tissues, discolorations, textures and details that were previously not considered relevant or seen in specific images. Replies related to the "Impact of apprentices' annotations on visual expertise" indicate a similar result. Plus, the results of the Wilcoxon signed-rank test indicate that the students perceived their own annotations as more helpful for observing images than the teacher's. In general, the apprentices were helped by both their own annotations and those of the teacher while observing the images. Because this section of the questionnaire was modelled on the work of Ko at al. (2019) and Lowenstein et al. (2019), it is important to point out that the students' positive replies indicate that annotations not only allowed them to observe images in a more general way, but also more specifically. Annotation fostered the identification of features such as colours, textures and specific tissues in the anomaly, and was useful in identifying elements not previously seen or considered relevant. At the same time, despite the positive results in the questionnaire, it is interesting to read these results in light of the group interviews, in which students put a greater emphasis on the impact of the teacher's annotations and use of descriptions. It is possible that the students might have undervalued the impact of their own annotations when it comes to visual expertise. Similar results were also seen for the descriptions scale, with most of the students agreeing that the descriptions allowed them to think about the images, integrate concepts, and memorise them. Interestingly, this result could provide an indication as to where to focus this kind of training. For instance, in the activities, a section on metacognition could be implemented that focuses on solidifying integration, memorisation and recall for different anomalies and their features.

In the group interview, the apprentices reported that they did not follow a specific way of observing the client's skin. Conversely, the teachers strongly felt the necessity to check the skin to find anomalies, warn the client in case of dangerous anomalies and check the status of treatment, indicating a more structured way of carrying out professional visual expertise. As shown in the questionnaire, the apprentices generally had a positive perception of annotations and description in visual expertise tasks, but they indicated that annotations are more beneficial in exercises, with the images depicting a full face compared with just an affected body part. The teachers recognised the didactical relevance of using annotations to highlight certain elements of the image and enhance the attention of the students while increasing their ability to recognise anomalies. The students also mentioned the importance of annotation to practice because they did not always have this chance at work.

The descriptions were useful for increasing attention and forcing the students to observe more intensively since they had to describe the images. Further, the apprentices indicated that the descriptions made them more focused, even if they were challenging. The teachers were positive about the descriptions and noted that they helped in supporting the visual expertise, identification and internalisation of the content. This also suggests that combining annotations and descriptions constitutes a powerful option for teaching about anomalies.

Both groups showed interest in continuing to use Realto, but with a slightly different format. For instance, the students pointed out that they preferred to use Realto during all the lessons, but for a shorter time. The teachers explained that they would like to explore the use of written annotations more.

Although the results are positive, it is important, to make some limitations of the study explicit. The first is surely due to use of the third year class (who already complete skin anomaly course) as a baseline group. Having two classes of the same year would have been a better choice but no other second year class was available in the area for the intervention. Another issue is related to the sample size of the experimental group which was rather small; having a larger sample could allow for more fine-grained analysis and more complex experimental designs. The small sample size limits the generalizability of the data but reflects the actual number of apprentices enrolled in the certificate and in that specific year.

Besides this limitation, we believe the results could be relevant for the general research on visual expertise and for the development of the profession and practitioners. Our contribution to the field rests can be incorporated in three main points:

- The positioning of the current research in vocational and education and training (VET) instead of higher education.
- The need of the apprentice beauticians to enhance their currently limited-in-time training on the visual expertise and identification of skin anomalies to become more competent professionals.
- The training material created for the present study combines elements of other trainings that already proved to be effective in other fields, such as1) the use of attention-guiding cues to train students' gaze (e.g., Boucheix & Lowe, 2010), 2) the use of technology-supported annotations to help professional dermatologists with skin anomalies (e.g., Ferreira et al., 2012; Eapen et al., 2020) and 3) repeated sets of images (e.g., Rimoin et al., 2015).

This research could open new ways to train visual expertise skills in many vocational professions. For instance, massage therapists could be trained to observe the patient's body in a more specific way and identify anomalies (e.g., rotation of the pelvis, pronation, etc.) that the patient is not yet aware of and that newcomers to the field might take time to recognise. Also, professions such as, for example, gardeners could improve their visual expertise of similar plants and anomalies (plant protection) that attack plants and that share similar features. In addition, apprentices in technical professions could benefit from training in technical drawings. There is a wide range of possibilities that are worth exploring with methods that include annotations and the description of images.

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