An innovative tool for olfactive learning with Tangible User Interfaces in MOOC learning for viticulture and enology learning

Raffaele Di Fuccio[a], Giusi Antonia Toto[b], Michela Ponticorvo[c], Anna Parola[c], Davide Marocco[c], and Orazio Miglino[c]

[a] *Smarted srl, Via Riviera di Chiaia 256, Naples, Italy*
[b] *University of Foggia, Via Arpi, 176, Foggia, 71121, Italy*
[c] *University of Naples Federico II, Via Porta di Massa, 1, Naples, Italy*

Abstract

The paper presents MERGO an EU-funded project that delivers a MOOC in enology and wine tasting combined with a laboratorial olfactory experience based on Tangible User Interfaces (TUI) paradigms. The focus of the article is on the description of the MERGO TUI prototype that allows the user to improve and train their olfactory knowledge, as procedural learning system. The users interact with a common olfactory learning kit enhanced with RFID technology and recognized by an active RFID antenna. In this way, the software propones exercises, hints and feedbacks for enhancing the olfactory competences connected to the lesson provided in the MOOC on enology, viticulture and wine testing.

Keywords 1

Instructional design, four-component instructional design, 4C-ID, complex learning

1. Introduction

Hybrid educational systems are rapidly improving their impact in the higher education practices, bridging distance learning and face-to-face lessons [10]. After the COVID-19 crisis, the need of new ways for teaching and learning emerged, and teaching institutions finds the distance learning as a possible solution for dealing this context. Nevertheless, a series of unprecedented dynamics have emerged, for example are emerging some resistances towards digital technologies. This approach is also related to the low perceived skills in managing digital environments. [11, 12]

In this context, the courses that suffered the greatest impact are those where it is not possible to release the practical learning from a theoretical teaching. These courses need of laboratorial components and experiential moments. Typically, in the MOOCs that are available, the declaratory learning (thus based on theoretical contents) is prevalent and traditionally supported by lessons and didactical materials with a verbal approach that could be covered with slides, videos, wikis, etc. The procedural learning in online courses could be done only with digital assets, as the inclusion of serious games [13], simulations, gamified approaches, and interactive resources [14]. These strategies are well-accepted but not useful for all the topics. One those subjects that could affect from the online is the enology and viticulture teaching. The academic lessons in enology are based on theoretical teaching, that are supported by an intense laboratory activity where the "student" could learn, with a guidance, in the acquiring the multisensorial skills for the wine recognition (olfactive, gustative and visual). Then, as it is typical in each training processes, the declaratory learning is consequently supported by lessons and didactical materials with a linguistic approach (slides, articles, etc.), [15] but for enology the procedural learning is need for the learning of the basic olfactory features of wines in laboratorial contexts, thus in

enology and wine tasting it is central the ability of the "sensory recognition". Commonly in wine tasting courses and enology higher education lessons, the theoretical lessons see the integration of specific didactic tools that allow to acquire a basic level of sensorial recognition. These practical learning phase has an expert (a sommelier or an enology lecturer) that guides the students in the sensory recognition of different scents. Typical learning approaches are represented by dedicated laboratories for the sensory analysis by using dedicated tools for the olfactory learning. These tools include some jars containing different odours, that are the single aromas found in wine, and then, in wine recognition.

New methodologies should be founded for the implementation and harmonization with a procedural learning that refers to experience and laboratorial activities. Something that is crucial in enology and even more in wine tasting, for the ability of recognition of basic level of sensorial recognition. In this way courses that needs a consistent part of procedural learning could be developed also with distance and hybrid contexts. A possibility is to connect the common didactic tools, with physical and tangible scent jars, with the digital interface [16], thus a re-mediation of some specific didactic tools that are common in face to face practice, that propose an olfactory learning in order to improve the ability of discriminate different odorants in the wine blends. New technologies are emerging, the mixed-realities (MR) technologies [23] and Tangible User Interfaces (TUIs) [24].

The sense of smell is often neglected in our life, but it has a relevant impact the learning [17] and in wine recognition [18]. Odors can influence moods, emotions [19, 20] and memories [21]: while pleasant odors can induce positive moods, unpleasant odors can induce negative ones [8, 22]

Moreover, the wine sector is very relevant in the European economy. The Eurostat statistics say that production of wine in Europe is relevant, and the EU is leader in this field: in 2018, the EU Member States exported €22.7 billion (bn) of wine, and imported a total of €13.4 bn. All told, the sold production of wine (including sparkling wine, port and grape must) in the EU was around 15 billion litres. The total area under vines in the EU was 3.2 million ha in 2015, representing around 45% of the world's total area under vines and the 1.8 % of the total utilised agricultural area.[2]

2. MOOC and enology

MOOCs are exploiting their impact in the higher education context, the number of courses on the most popular platforms are increasing. The enology sector is as well included in this field.

Table 1
Wine tasting and enology MOOCs

MOOC name	MOOC provider	Description
Vine & Wine	FUN	Scientific and Technological bases for wine professionals work
World of Wine: From Grape to Glass	edX	Knowledge of sensory attributes, vineyard management practices, winemaking techniques
Introduction to Wines	OpenLearning	Food matching, wine labels understanding, plant sources
MOOC # OWU: Open Wine University (University of Vine and Wine, for All)	EMMA	An in-depth look at the universe of vine and wine, several general themes around the vineyard and the wine
OWU2 – Open Wine University 2	FUN	Bottling and aging, including wine economy, history and communication and impact of climate change in wine

Different higher educational institutions (HEIs) developed online courses through the MOOCs for the wine field that address the relevant impact in the local economies including the increasing need of professionals with scientific competences and specific knowledge and the new wine enthusiasts.

Some examples of these courses are the "Wine Tasting: Sensory Technique for Wine Analysis"[3] on Coursera platform developed by UCDAVIS University of California; or the EU courses of the "Open Wine University"[4] on the EMMA platform delivered by the University of Burgundy, that developed also a second version of this MOOC. All these examples, shown in the Table 1, are limited to a declarative approach because these are conceived as online courses that teaches the main features of the wines, also for hobby and for professional purposes, including food matching. The themes are discussed and proposed to the learners as static contents. The students could learn the characteristics of the wine, but all the MOOCs listed have not solutions for the procedural learning based on the experience, because in distance learning is impossible to provide lessons using a laboratorial approach. It is fundamental to underline that in the enology and wine tasting the procedural approach represents the key on this sector, because the sensorial learning is one face of the medal.

Inserting laboratorial sections applying a sensorial learning, including the sense of smell and taste, is a complete novelty for MOOCs. There are some preliminary studies that propose solutions for the integration of the mobile learning in the MOOC, in particular detecting divided attention in students [25]. Other studies work on wearables, so the idea is to collect information from these tools (i.e. heart rate) for managing in an efficient way the learning [26]. However, in scientific literature is a complete innovation the application of tangible objects to be used with a sensory approach in the real environment by the students, connected to a classical MOOC. The students by smelling, by touching, could learn by experience, performing exercises drafted by professors, and all the practical exercises are recorded and orchestrated by the digital interfaces.

3. Tangible user interfaces and olfactory learning

Tangible user interfaces (TUIs) couple physical representations (e.g., spatially manipulable physical objects) with digital representations (e.g., graphics and audio), yielding user interfaces that are computationally mediated but generally not identifiable as "computers" per se. [30]

Thus, Tangible User Interfaces (TUIs) [24] enable the user to interact with tangible and multisensorial objects, then objects that contain odours, they could be recognized by a digital component.

In the literature the are different examples of this kind of solutions [1, 2] that applies tangible user interfaces for manage olfactory stimuli. Most of the solutions do not impact on the olfactory learning or address it in a partial way. TUIs solutions that involve the olfactory sense cover application that emit smells.

One of them is represented by the Scented Pebbles [4]. It is a collection of interactive lighting objects for the creation of a multisensory ambience with a mix of light and smell. The user handles the prototype and touching the tangible material the system changes its colour and emits a particular scent.

The multisensory approach derived by sight and smell is explored also by SensaBubble [6]. The prototype is chrono-sensory mid-air system that generates bubbles of specific sizes along a directed path that contain scents.

Another application is clayodor [3] made as a tangible user interface manipulable by the user, provided as clay-like malleable material. When the user re-adapts the shape of the material, the system emits a different odour mix. The prototype works due a pressure sensing multi-touch mat controlled by an Arduino connected to a piezoelectric transducer system.

In the learning sector could be itemized the Smelling Screen [7] that is an olfactory display that generates an odour with airflows that emanates the odour in a specific region of the screen. The odour

is generated when a specific image is shown on the LCD screen, that could have a relevant role in the learning process.

Other prototypes deliver the scent from olfactory interfaces located on-face. The prototype is called On-Face Olfactory [5] and release selected odours in specific moments.

An application of TUI in wine sector is developed by Carulli et al. [9]. This prototype combines visual, sound, tactile and olfactory technology to simulate a wine tasting experience. The application is made as a glass that emits specific odours, the sounds related to a video displayed on a LCD screen.

Finally, another prototype applied in the wine sector is SNIFF. SNIFF is an integrated software and hardware environment for the assessment of the senso of smell including a gamified approach [29]. SNIFF provides 30 smelling jars that could be recognized by an active RFID antenna connected to a software that provides exercises, hints and feedbacks.

This last example is a candidate to develop a MOOC on the "Wine tasting" argument, and at the same time, allowing the procedural learning based on the olfactory recognition. It applies new technologies with the strong support of autonomous game-based learning and learning analytics, which is impossible with the traditional "analogic" tools on the market. Some research prototypes [27, 28] has been developed in order to improve the olfactory learning about simple odour stimuli supported by a digital tool that includes artificial tutors able to guide the learning process.

Multisensory user experiences are increasing its popularity due the Internet of Things (IoT) devices. These tools, delivered as virtual or tangible, are used in different contexts, and for different purposes. As proposed by Bordegnoni et al. [8], two main types of applications can be identified:

- multisensory user experiences for the improvement of traditional products and services;
- multisensory user experiences for the simulation of real experiences.

In this field, the traditional learning in wine tasting provides courses with slides or face-to-face lessons using books and videos, that are coupled with experiential phase where the students have a sensorial training, for increasing skills in wine assessment by taste and smell. The idea is to provide a multisensory user experience using hybrid interfaces, applying the paradigm of tangible user interfaces.

The application of TUIs associated with a MOOC will have an important expected impact, because the students will have the possibility to train themselves with a traditional MOOC paired with tangible odour game designed for enology and wine tasting that exploits the knowledge of the sense of smell. If combined these two modules, the student could concretely learn the initial concepts of wine tasting or train their olfactory skills, embedded in an enology course.

4. The MERGO project

A MOOC coupled with laboratorial activities based on the application of TUIs is in development in a European project funded by the European Commission called MERGO[5] [16]. The complete title of the project is "Mooc in Enology aimed at Reinforcing competences applying Game-based approach and Olfactive learning for the wine tasting".

The name comes from the Latin "mergo" that means "dive", "immerse", "plunge", a figurative action that a wine taster has to perform when is ongoing an assessment of a glass. In order to discriminate all the scents, all the olfactory notes, about a bouquet of a specific wine, the taster needs to "immerge" his/her nose in the glass for catching all the olfactory stimuli needed for a correct understanding of a certain wine.

The project MERGO aims to bridge the MOOC learning with the procedural learning for the recognition of sensory features using Tangible User Interfaces (TUIs). MERGO develops ICT innovative tools that allow the student an autonomous training with olfactory stimuli and applying a validated framework delivered with a scientific approach, applying artificial intelligence modules (adaptive artificial tutors) [30]. Another asset is the multilingualism approach: the hybrid course with the coupling of MOOC and tangible environment, will be translated in six languages, namely English,

---

[5] http://mergoproject.eu/

Italian, Portuguese, Turkish, Croatian and French. Another scope of the MERGO project is to exploit the regional excellences and the cultural differences in the wine sector.

As told before, the MOOC will include theoretical lectures based on enology topics, i.e. vineyard and the grape quality, organic wines, wine defects, sensory evaluation of wine, wine tasting techniques, valorisation of autochthons vineyards, production chain, etc. The course will offer online materials, such as podcasts, videos and, whenever possible, webinars. Practical experiences during the course will be entirely based on the gamified approach that applies tangible user interfaces.

MERGO represents a complete innovation in the field of sensory recognition. It allows the presence of systems for a home olfactive learning with the interaction of a "virtual" teacher. In commerce there are kits for the sensory analysis, or using publishing tools for the olfactory learning[67]. Typically, these learning tools need a check that implies to know which the related scent is contained in the odour jars, reducing the longevity of the training kit. The student needs the supervision of an expert or a teacher, or to have instant feedback discovering on a paper sheet which is the right jar for the required task. In MERGO the students use the kit enhanced by the ICT component, applying the tangible user interface paradigm and assessing the odours using a gamified approach in a blind mode.

The Tangible User Interfaces (TUIs) allows the user to interact with tangible and multisensorial object, then jars that contain odours, and consequently they could be recognized by a digital component, that is an active table equipped with an RFID active antenna (Figure 1). This is possible using RFID/NFC technology: each odour jar has a NFC tag pasted on the back and each tag contains all the information needed for the gamified task (Figure 2). The NFC tags are very thin and it considered a low-cost technology.

Figure 1: The active table that recognize the odor jars.

The active antenna in Figure 1 includes: (1) RFID antenna ANT_HF_310 X 180 (Antenna HF 310 mm × 180 mm), (2) RFID reader BlueRFID HF[1], (3) Main controller (with RX/TX module USB/Wi-Fi) that include a Particle Photon (a tiny, reprogrammable Wi-Fi development kit for prototyping)[2], with a STM32F205 120 MHz ARM Cortex M3 and Cypress BCM43362 Wi-Fi chip (Single band 2.4 GHz IEEE 802.11b/g/n), (4) battery module equipped with MCP73831 for LiPo charging and a MAX1704X for fuel gauging[3] and a LiPo Battery 3000 mAh. [31]

As previously described the integration with the MOOC is a relevant novelty, as an innovative pedagogical approach for distance learning. It elicits the possibility to learn with a MOOC that provides normal lessons (slides, videos, questionnaires) in a typical declarative learning and with a practical tool that supports the procedural learning and the practical experience, also at home. In enology and wine-tasting sector, the procedural learning could directly involve the basic olfactory learning, applying in practice what he/she is studying in the MOOC and performing as in physical wine tasting learning,

---

using the odour kit for the improvement of the olfactory knowledge supported by a ICT platform (Figure 1 & 2).

Figure 2: The olfactory kit: odor jars enhanced with RFID tags recognized by the active table. The user smells the odor jar after the task assignment proposed by the software. The user could place the odor jar on the active table for replying to the question and solve the olfactory assignment in a gamified environment.

An important aspect of the project is to develop the exercise for the MERGO odour game with TUI, starting from the lessons in the MOOC and co-created with experts in the sector, involving a broad number of participants. The project applies a co-creation approach, involving students form the faculties of agriculture, enology and food technologies, professionals in the wine sector that aims to train their skills, sommeliers, tasters and persons that work in food sector (restaurants, hotel, etc. and finally, enthusiasts of wine tasting.

5. Conclusions and next steps

The MERGO project aims to bridge the development of a MOOC in enology, viticulture and wine tasting applying an innovative tool based on tangible user interfaces that allows the students to train and learn their sensory skills (smell and taste). The traditional olfactory kits are enhanced with NFC/RFID tags (Figure 2), recognized by an active table equipped with an active antenna (Figure 1).

The learners have the opportunity to study the traditional course in enology and wine tasting with contents delivered by lecturers, professors and experts from different countries (Italy, Portugal, France, Croatia and Turkey) in universities and wine associations. This implies a declarative learning, a transmission of knowledge using videos, slides and webinars. For a procedural learning, the MOOC is empowered with real laboratorial activities, giving the opportunity to the students, performing them in their homes. They only need an olfactory kit enhanced with low-cost RFID/NFC technology and a common active RFID antenna [27] developed by the project. In a traditional wine tasting course held face-to-face, the students buy the olfactory kit. In this case the only added tool is the RFID antenna.

The MERGO project will implement this innovative approach involving professionals from the wine sector with a co-creation approach. One of the aims of the study will be to measure the impact of tangible user interfaces and the procedural learning in enology courses, analyzing the effect for the students and their acceptability of the technology. One important focus will be on the usability of the system and the integration between the MOOC and the odor game system based on TUIs.

6. Acknowledgement

7. References

[1] J. Broscheit, Q. Wang, S. Draheim, K. von Luck, Towards Atmospheric Interfaces. In Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction, 2021, pp. 1-7.

[2] T. Nakamoto, (Ed.), Human olfactory displays and interfaces: Odor sensing and presentation. IGI Global, 2013.

[3] C. H. L. Kao, E. Dreshaj, J. Amores, S. W. Leigh, X. Benavides, P. Maes, K. Perlin, H. Ishii, clayodor: Retrieving scents through the manipulation of malleable material. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction,* 2015, pp. 697-702.

[4] Y. Y. Cao, N. Okude, Scented pebbles: interactive ambient experience with smell and lighting. In *Proceedings of the ninth international conference on tangible, embedded, and embodied interaction*, 2015, pp. 409-410.

[5] Y. Wang, J. Amores, P. Maes, On-face olfactory interfaces. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 2020, pp. 1-9.

[6] S. A. Seah, D. Martinez Plasencia, P. D. Bennett, A. Karnik, V. S. Otrocol, J. Knibbe, … S. Subramanian, SensaBubble: a chrono-sensory mid-air display of sight and smell. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2014, pp. 2863-2872.

[7] H. Matsukura, T. Yoneda, H. Ishida, Smelling screen: development and evaluation of an olfactory display system for presenting a virtual odor source. *IEEE transactions on visualization and computer graphics*, (2013), *19*(4), 606-615.

[8] M. Bordegoni, M. Carulli, F. Ferrise, Improving multisensory user experience through olfactory stimuli. In *Emotional Engineering,* Springer, Cham, 2019, *Vol. 7* (pp. 201-231).

[9] M. Carulli, M. Bordegoni, F. Ferrise, A. Gallace, M. Gustafsson, T. Pfuhl, Simulating multisensory wine tasting experience. In: DS92: Proceedings of the DESIGN 2018 15th international design conference, (2018), pp 2177–2186

[10] P. Limone, (2021). Towards a hybrid ecosystem of blended learning within university contexts. In *CEUR Workshop Proc.*, Vol. 2817, 2021.

[11] G. A. Toto, P. Limone (2021), From Resistance to Digital Technologies in the Context of the Reaction to Distance Learning in the School Context during COVID-19. *Education Sciences*, *11*(4), 2021, 163.

[12] C. Damşa, M. Langford, D. Uehara, R. Scherer, Teachers' agency and online education in times of crisis. *Computers in Human Behavior*, *121*, 2021, 106793.

[13] M. Freire, Á del Blanco, B. Fernández-Manjón, Serious games as edX MOOC activities. In *2014 ieee global engineering education conference (educon)* 2014, pp. 867-871.

[14] D. Davis, G. Chen, C. Hauff, G. J. Houben, Activating learning at scale: A review of innovations in online learning strategies. *Computers & Education*, *125*, 2018, 327-344.

[15] L. Pérez-Hernández, Mobile Learning for the Teaching of Theoretical Concepts to Undergraduate Students. In *CSEDU (2),* 2015, pp. 540-545.

[16] L. Martiniello, L. Borrelli, G. A. Toto (2021). Design of a MOOC for teaching and research: the innovative experience of the MERGO project. In *CEUR Workshop Proc.*, Vol. 2817, 2021.

[17] D. A Wilson, R. J. Stevenson, R. J. Stevenson, R. J. Stevenson, *Learning to smell: olfactory perception from neurobiology to behavior*. JHU Press, 2006.

[18] M. Bende, S. Nordin, Perceptual learning in olfaction: professional wine tasters versus controls. *Physiology & Behavior*, *62*(5), 1997, 1065-1070.

[19] R. S. Herz, Are odors the best cues to memory?: a cross-modal comparison of associative memory stimuli. Ann N Y Acad Sci 855, 1998, 670–674

[20] E. Vernet-Maury, O. Alaoui-Ismaili, A. Dittmar, Basic emotions induced by odorants: a new approach based on autonomic pattern results. J Autonomic Nervous System 75, 1999, 176–183

[21] H. Ehrlichman, L. Bastone, The use of odor in the study of emotion. In: Van Toller S, Dodd GH (eds) Fragrance: the psychology and biology of perfume. Elsevier, New York, 1992.

[22] G. Epple, R. S. Herz, Ambient odors associated to failure influence cognitive performance in children. Dev Psychobiol 35, 1999, 103–107

[23] M. Gardner, J. Elliott, The Immersive Education Laboratory: understanding affordances, structuring experiences, and creating constructivist, collaborative processes, in mixed-reality smart environments. *EAI Endorsed Transactions on Future Intelligent Educational Environments*, *14*(1), creators-Gardner, 2014.

[24] H. Ishii, H, The tangible user interface and its evolution. *Communications of the ACM*, *51*(6), 2008, 32-36.

[25] X. Xiao, J. Wang, Undertanding and detecting divided attention in mobile mooc learning. In *Proceedings of the 2017 CHI conference on human factors in computing systems* 2017, pp. 2411-2415.

[26] P. Pham, J. Wang, AttentiveLearner: improving mobile MOOC learning via implicit heart rate tracking. In *International conference on artificial intelligence in education* Springer, Cham, 2015, pp. 367-376.

[27] O. Miglino, A. Di Ferdinando, R. Di Fuccio, A. Rega, C. Ricci, Bridging digital and physical educational games using RFID/NFC technologies. *Journal of e-Learning and Knowledge Society*, *10*(3), 2014.

[28] M. Ponticorvo, R. Di Fuccio, F. Ferrara, A. Rega, O. Miglino, Multisensory educational materials: five senses to learn. In *International Conference in Methodologies and intelligent Systems for Techhnology Enhanced Learning*, Springer, Cham., 2018, pp. 45-52.

[29] M. Ponticorvo, F. Ferrara, R. Di Fuccio, A. Di Ferdinando, O. Miglino, SNIFF: A game-based assessment and training tool for the sense of smell. In *International Conference in Methodologies and intelligent Systems for Techhnology Enhanced Learning*, Springer, Cham, 2017, pp. 126-133.

[30] A. Di Ferdinando, M. Schembri, M. Ponticorvo, O. Miglino, Agent based modelling to build serious games: The learn to lead game. In *International Work-Conference on the Interplay Between Natural and Artificial Computation*, Springer, Cham, 2015, pp. 349-358.

[31] R. Di Fuccio, G. Siano, G., A. De Marco, The activity board 1.0: RFID-NFC WI-FI multitags desktop reader for education and rehabilitation applications. In *World Conference on Information Systems and Technologies*, Springer, Cham*, 2017, pp. 677-689.