EVALUATION OF A VIRTUAL LEARNING ENVIRONMENT IN THE DEVELOPMENT OF WINEMAKING COMPETENCES BY TRAINEES

AVALIAÇÃO DE UM AMBIENTE VIRTUAL DE APRENDIZAGEM NO DESENVOLVIMENTO DE COMPETÊNCIAS EM VINIFICAÇÃO POR APRENDIZES

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Abstract. This paper is a case study that describes and evaluates a virtual learning environment (VLE) with seasonal inexperienced workers (trainees). The VLE contains 3D and 2D scenarios of a modern winery that animates and simulates seven winemaking processes, based on the Chilean National Work Competency (WC) Standards. The aim of this study was to evaluate the WC of winemaking developed by trainees in this VLE. The WCs developed by trainees were verified in field by an expert in three different wineries. Furthermore, elements of WC such as traceability, job safety and hygiene were evaluated by surveys. The trainees displayed a positive performance when interacting with the hands-on real winery equipment after the training with VLE. The significance of this study is the analysis of a novel VLE based on a winery and a winemaking process that can become an efficient learning tool for developing work competences in trainees.

Keywords: virtual winery; interactive learning environments, winemaking processes, VLE, competences, job safety, traceability, hygiene.

Resumo. Este trabalho é um estudo de caso que descreve e avalia um ambiente virtual de aprendizagem (AVA) com trabalhadores sazonais sem experiência (aprendizes). O AVA contém cenários 3D e 2D de uma vinícola moderna, com animação e simulação de sete processos de vinificação, com base nos Padrões Nacionais de Competência de Trabalho (WC) do Chile. O objetivo deste estudo foi avaliar o WC da vinificação desenvolvido pelos aprendizes neste AVA. Os WCs desenvolvidos pelos aprendizes foram verificados em campo por um especialista em três vinícolas diferentes. Além disso, elementos do WC como a rastreabilidade, segurança do trabalho e higiene foram avaliados por pesquisas. Os aprendizes apresentaram um desempenho positivo ao interagir com o equipamento da adega real, após o treinamento com o AVA. A importância deste estudo é a análise de um novo AVA baseado em uma vinícola e um processo de vinificação que possa se tornar uma eficiente ferramenta de aprendizagem para o desenvolvimento de competências de trabalho para os aprendizes.

Palavras-chave: adega virtual; ambientes interativos de aprendizagem; processos de vinificação; AVA; competências, segurança do trabalho, rastreabilidade, higiene.

INTRODUCTION

Every year, the seasonal food industry must recruit seasonal workers for the intensive work period. For different reasons companies do not often hire experienced workers, and must develop and implement apprentice training where special emphasis is placed on hygiene, job safety and traceability which are mandatory training aspects to meet certification requirements of almost all food exporting companies (Egana et al, 2007). The training method becomes particularly important for the seasonal food industry (McGehee et al., 1961), and especially for those who export to very demanding consumers. Chilean wine is a seasonal food industry which is highly oriented to demanding markets. Bisson et al., 2002 indicated that the wine industry requires producers to understand the latest developments in wide-ranging disciplines of science and technology. In this sense, Virtual Learning Environments (VLEs) breakdown the barriers that reality imposes, as in the example of the access to sophisticated equipment that allows trainees a virtual "hands-on" experience in the delicate and precise work of winemaking.

The increase in the complexity of technical equipment and machines in the industry demand a greater periodicity of training and higher level of employee qualifications. The wine industry requires skilled workers to operate the new machinery and technology. However, the rising costs and efforts required to qualify these technicians pressure training centers to seek new methods and tools to carry out training, often with lower investment. In order to maintain a competent workforce, prepared for the rapid influx of new and changing technologies in winemaking, the National Commission for Scientific and Technological Research of Chile (CONICYT, 2016) supported the concept and construction of a VLE (called BITWINE). The conceptual framework (BITWINE, 2014) was based on the National Competency Standard for Winemaking Operators outlined in CHILEVALORA (2016). No such complete programs existed prior to 2016, and it seems that only SECONDLIFE (SECONDLIFE, 2016) has some virtual cellars, but with limited design and interaction. However, the VLE under consideration here, BITWINE, corresponds virtually to an entire winery equipped with modern technology that was built to enable the "being there" experience and promotes the hands-on practice (BITWINE, 2016). The VLE was aimed to development technical skills as well as the abilities related to job safety, hygiene and traceability, which constitute, at the same time, the profile of a competent winemaking operator according to the Chilean wine industry standard (CHILEVORA, 2016).

Rutten et al. (2010) made an exhaustive meta-analysis of 500 VLE which resulted in a positive effect of virtual simulators on student learning. BITWINE has also proven to be helpful in improving the learning of winemaking in high school and university students compared to the more traditional way (Cornejo and Cubillos, 2014; Bravo, 2014). Although BITWINE has been positively evaluated by formal students, the effect of BITWINE on seasonal inexperienced workers (trainees) has not yet been studied. In general, trainee operators in VLE have been studied less as study subjects than formal students (Al-Hussein et al. 2006; Brough et al. 2007; Sá and Zachmann, 1999). The aim of this study was to evaluate winemaking competences developed by trainees in a virtual learning environment. As VLEs dramatically shift the location and timing of education and training by means of providing visual, experiential, and self-directed learning within an environment of practice and repetition without on-the-job stress (Sá and Zachmann, 1999), we hypothesized that BITWINE could reinforce the development of winemaking competences in seasonal inexperienced workers (trainees).

MATERIALS AND METHODS

BITWINE is a software created and registered by the Universidad Católica del Maule and Universidad Santo Tomás in Chile. This is a Spanish language VLE developed with Unity® Language Game Development Engine (UNITY, 2014), which enables the creation of artificial intelligence and motion within a 3D environment. Furthermore, a set of 2D animations (infographics) and learning activities were constructed by using ActionScript of Adobe Flash Player ®. The requirements for accessing BITWINE are computers with an internet connection of 2048 Kbps (download)/1024 Kbps (upload), DirectX (Pixel Shader 2.0) a graphic card, and a computer mouse

The BITWINE simulations were defined and described by oenology teachers, winery oenologists and expert winery operators, through qualitative and quantitative surveys; they determined the most difficult winemaking processes to teach, as well as the most common mistakes that winemaking operators make in

these processes. The BITWINE storyboard finally included seven wine production processes: crushing, fermentation, pressing, clarification, filtration, cold stabilization, and aging (Figures 1, 2 and 3).

The case study of the evaluation of seasonal inexperienced workers (trainees) was carried out in three wineries, immediately before beginning the real winemaking process, during the apprentice training in the 2013 harvest season. The trainee sample groups were three (i.e., n = 10, 8 and 12 trainees respectively in wineries one, two and three) and all of these groups received the same instruction with identical conditions, but in three different days each. The training with BITWINE took place for one day with the same winemaking tutor who taught the trainees with computers loaded with BITWINE. Before the training period, workers answered a questionnaire about their knowledge and experience in winemaking. This information was considered as the baseline situation (i.e., without BITWINE). Then, the same three groups of workers (from the baseline situation) learned about the winemaking equipment, inputs, processes, and the related standard of hygiene, job safety and traceability in the BITWINE VLE. The day after the training, the tutor administered an in-field checklist by observing worker performance in real tasks. The observations included the following competency elements of the winemaking competence standards of CHILEVALORA (2016): winemaking knowledge, technical skills as well as the job safety, hygiene and traceability aspects of the winemaking process. The difference between baseline situation and the further evaluation was evaluated with a t-test. Furthermore, after the training period finished, these 30 trainees were surveyed about the capacity of BITWINE to teach safety, traceability, and hygiene topics. Tutor observation checklists and opinion surveys were averaged and then expressed as a percentage of all of the trainees.

RESULTS AND DISCUSSION

Training assisted by BITWINE

The training period with BITWINE consisted on reviewing the animations of crushing, pressing and fermentation that belonged to the seasonal winemaking process. These animations describe the equipment and supplies, the procedure from the delivery of the work order until the process ends, with the associated industrial safety, hygiene and traceability norms. Once trainees revised the 2D material, trainees were able to carry out a simulation in the 3D virtual environment, where users interacted with equipment in the virtual winery by controlling an avatar and interacting with tanks, barrels, presses, pumps, wine hoses, tank valves, etc (Figure 1 and 2).

The training was carried out with BITWINE VLE in their 2D and 3D scenarios. Richards and Taylor (2015) indicated that both of them are valuable learning tools; the 3D virtual winery introduced trainees into this new experience and gave them a sense of reality, location and context (Sá and Zachmann, 1999), while 2D flash animations gave them understanding of the winemaking sub process and their related quality control (Fig. 1).

Figure 1. Graphic 3D view of fermentation tanks/vessels (*left*). 2D animation of a destemmer-crusher that is processing white grapes (*right*).

Winery operators are exposed to injuries and illnesses that result in economic losses, especially during vintage. The World Health Organization (2008) has estimated the costs related to job safety in 4 to 5% of the gross domestic product. The knowledge of safety encourages trainees to learn about personal protective equipment and safe work practices (Burke et al., 2002). In this context, BITWINE is a training tool that teaches about job safety. The positive relationship between safety training and compliance with wearing personal protective equipment have been researched by Smith-Crowe et al., (2003). Figure 2 shows images of BITWINE job safety.

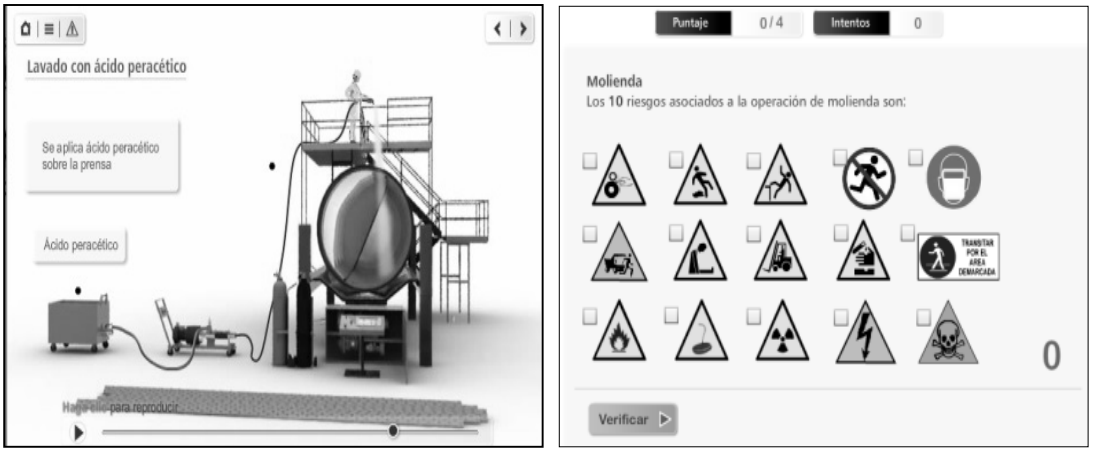

Figure 2. Animation of the washing of press equipment (left) and some hazard pictograms (right).

Job safety and hygiene are the parts of industrial hygiene which are defined as "the science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors, or the stress that arises in or from the workplace, which may cause sickness, impaired health and well-being, or significant discomfort among workers or among the citizens of the community" (Plog, 2002). However, an important issue especially in small food businesses, is the low flexibility of hygiene training (Harris, 1995). BITWINE demonstrated that this issue can be overcome by the permanent possibility of repetition in the VLE. As can be seen in Fig. 2, users learned about the steps to meeting hygienic requirements for the press equipment, as well as job safety norms.

Traceability is also a quality procedure used to assure food safety norms as well as a requisite for wineries to sell wines in the European Union; the wineries must trace their products throughout their various stages, starting with the suppliers and up until the arrival of the end products to the final consumers (Alfaro and Rábade, 2009). In the BITWINE VLE, the simulations began with a random work order and, while users advanced, they moved through the assigned tasks in order to complete the work order. In Figure 3 the avatar has a work order in hand, which was progressively completed during the simulation. This task enforced the importance of the traceability, which is defined, according to the Webster's Dictionary, as "the ability to follow or study the history of a certain activity, or a process, in detail or step by step."

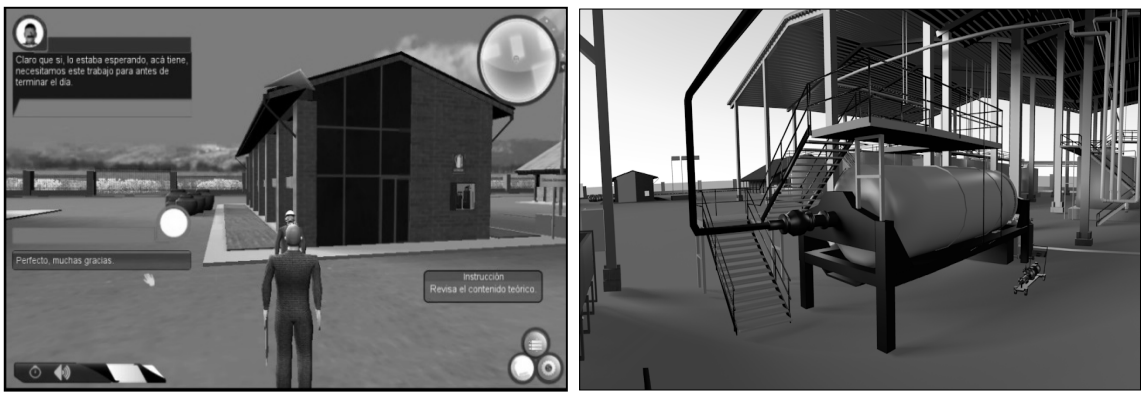

Figure 3. The avatar (user) dialogues face to face with a supervisor with a work order in hand (left). A 3-D scene of the press equipment, which is operated by the user in the pressing simulation (right).

EVALUATION OF THE COMPETENCES ACQUIRED BY INEXPERIENCED WORKERS

The baseline status (Table 1) confirmed the low degree of trainees experience. After they used BITWINE, a checklist applied in-field revealed a significantly better performance ($p<0.01$). The progress reached during the induction or training period was remarkable. The new trainees went from very low levels (i.e., Mean = 18.28 ± 6%) to much higher levels (i.e., Mean = 87.01 ± 18.6%) of skills achieved (Table 2).

In Figure 2 and 3 there are images of a press machine which is a complex hands-on equipment. The pressing as well as the filtering operations are also complex processes in a real winery. BITWINE explains the process and its operation. As shown in Table 1, only 40 % know how operate a press equipment after training. Compared to other operation responses presented in table 1, this rating was the lowest evaluated. However, the skills to operate a press increased from 9.3 (baseline situation) to 40%. Based on this improvement, we postulate that VE enables the users to operate those types of oenological machines, thus promoting technical skills (Sá and Zachmann, 1999).

The skills developed in VLE can be used to operate real equipment (Ye et al. 1999) due to their "learn by doing" approach (Tam et al., 1999). For instance, the trainees went from "knowing the crushing process" (20%) to "recognizing how to operate the crushing equipment, while it was running" (92%), and on to "how to use the SO2 input" (100%). Furthermore, trainees improved the quality of the industrial processes, as Zhou et al. (2012) explained as an advantage of VLE. This included the good practice of hygiene (90-100%), the recording of work orders (90%), and the safety precautions (87%) (Table 1).

Since trainees presented an adequate performance in the technical skills as well as in the application of hygiene, safety and traceability norms (Table 1), we wanted to know their opinions about how BITWINE included these elements of the winemaking competences (Table 2).

Table 1. New skills acquired by trainees in the winemaking process. Median percentage of positive answers in three wineries during the induction period

Self-evaluation before intervention with BITWINE **(baseline situation)**	Positive answer (%)
Have you ever worked in a winery?	27.3
Have you ever received winery training?	16.3
Do you know the crushing process?	18.4
Do you know the pressing process?	9.3
Do you know how to move wine between tanks?	23.1
Do you know how to inoculate must with yeast?	21.6
Do you know how to use the safety equipment for this task?	14.5
Competences in the crushing process after training with BITWINE. The workers know how:	
To maintain the work order during the work day	90.0
To recognize crushing equipment and all its parts	100
To recognize how to operate crushing equipment while it is running	92.0
|To recognize the use of SO_2 well	100
To recognize how to practice good hygiene	90.8
To recognize safe work	87.1
Competences in the pressing process after training with BITWINE. The workers know how:	
To understand the work order	96.7
To recognize the pressing equipment and all its parts	100
To recognize pressing alternatives	84.4
To operate the press by using the control panel	40.0
To apply oenological inputs during pressing	100
Competences in the fermentation process after training with BITWINE. Workers know how:	
To keep records of the work order during a work day	83.3
To apply oenological inputs during fermentation	94.4
To recognize the steps in good hygiene	100
To recognize how to take safety precautions in fermentation	86.6

Table 2. Trainees opinions regarding the BITWINE capacity to produce specific learning outcomes.

Categories	Question about BITWINE	Agree completely (%)	Agree somewhat (%)	Neither agree nor disagree (%)	Disagree somewhat (%)	Completely disagree (%)
Safety	Does it show the safety signs?	56.9	43.0	0.00	0.0	0.0
	Does it display care about safety risk?	43.3	44.1	12.5	0.0	0.0
	Does it promote the use of PEE[1]	0.0	93.0	6.9	0.0	0.0
Traceability	Does it promote the traceability in work orders?	8.3	43.9	47.7	0.0	0.0
	Does it indicate the work order?	13.9	24.7	61.4	0.0	0.0
Hygiene	Does it have enough detail on the steps to good hygiene?	91.1	8.9	0.0	0.0	0.0
	Does it indicate the steps to good hygiene?	14.4	85.5	0.0	0.0	0.0
	Does it explain the proper use of water in cleaning?	77.0	23.0	0.0	0.0	0.0

1. PEE: personal protection equipment.

From the results of Table 2 it seems that BTWINE promoted a "safety attitude" and fostered the perception of risk, hazard, and safety job in the winemaking environment. Trainees learnt how to use personal protective equipment as well as safety work practices in specific tasks, as is required by CHILEVALORA (2016) for each winemaking competence. The trainees also developed the ability to retrace steps and verify that certain events have taken place. Alfaro and Rábade (2009) indicated that traceability has competitive advantages in solving possible product safety problems, in order to improve the manufacture's understanding of its systems, as well as to supplement the quality controls. This could be attributable to the fact that virtual environments improve users ability to move from an abstract thought to concrete implementation (Cheng and Wang (2011).

Finally, although BITWINE did not cover all of the dimensions of a work competence (i.e., ability, knowledge, understanding, skill, action, experience and motivation listed in Winterton et al., 2006), it helped to develop at least the first dimensions of a work competence. The study of experience and motivation dimensions, which allow reach higher competences degrees, is a pending task.

CONCLUSION

Our results corroborate that BITWINE helped to improve the performance of trainees as they developed the skills, knowledge and the abilities to work with hygiene, safety, and traceability norms. These are elements of work competences that this VLE incorporates in the teaching-learning process. Based on this, we can speculate that this VLE model, aimed to develop work competences in inexperienced seasonal workers in the wine industry, could also be applied to other food industries. However, more research is needed in order to determine which industries and processes would benefit from using VLE as a training device for trainees, or from using VLEs for renewing the knowledge and the skills for technical development.

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