Virtual environments for vocational training: user experience in culinary education

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Abstract

Although Virtual Environments (VE) with various levels of immersion have been used and evaluated in vocational and adult training with positive results, no such environments exist for culinary education. The aim of this study was to design a VE for culinary education and evaluate it in terms of user experience with two different levels of immersion: low (desktop) and high (Head Mounted Display - HMD). Twenty-four students and graduates of an Institute of Vocational Training specializing in either ICT or Culinary arts participated in this study. Results showed no significant differences in terms of spatial presence, usability and workload between the two interfaces. Nevertheless, participants using the HMD interface needed more time to complete a recipe and experienced much higher simulator sickness. It seems that the lower immersion interface is more appropriate for this specific VE.

Keywords: Virtual Environments, Head Mounted Display, presence, usability, workload, Simulator Sickness

Introduction

Virtual Environments in vocational training

Vocational training intends to prepare students to work in a trade or craft. It is often skill-oriented and is based on learning by doing (Mellet-d'Huart, 2009). This means that it involves hands on training that is carried out in a laboratory, workshop or on-the-job. This requirement makes vocational training less flexible, costly and difficult for distance learners. Information and Communications Technologies (ICT) seem to have the potential to leverage the cost and quality of vocational training (Hsu & Chien, 2015).

ICT in vocational training usually take the form of Learning Management Systems (LMS), instructional videos, simulations, games and virtual environments (VE). These tools don't have the limitations that are related to traditional face to face learning. They can be accessed anytime and anywhere and because they are user-driven and self-paced they are more comfortable, flexible and enjoyable for both the local and distance learner (Brown, Mao, & Chesser, 2013; Cawley, 2011; Mills & Douglas, 2004). In addition, they are cost effective, for both students (less transportation and living costs) and institutions (fewer infrastructure, faculty, administration, supervision) (Brown et al., 2013; Cawley, 2011). Research supports that ICT-based learning has similar learning outcomes to traditional face-to-face approach (Brown et al., 2013).

Maybe the most advanced instances of training ICT are virtual environments. They are computer generated 3D spaces in which users can navigate freely and interact with objects or other users. These virtual worlds can simulate the context, tools, and actions that the trainees need to learn. They are usually used for training in areas that are too dangerous, too expensive or unreachable (Freina & Ott, 2015; Mellet-d'Huart, 2009). They are considered

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powerful tools for the training of a wide range of trainees: from industrial workers and soldiers to pilots, astronauts and surgeons (Borsci, Lawson, Jha, Burges, & Salanitri, 2016; Mellet-d'Huart, 2009). Training in VEs can aim at acquiring procedural skills or more higher order skills like abstract reasoning and problem solving under stress (Borsci et al., 2016; Freina & Ott, 2015). However, VEs can also be used to enhance training even when it is feasible in the real world (Mellet-d'Huart, 2009). They can motivate and excite the learner and their interactivity allows for more constructivist approaches to learning (Freina & Ott, 2015; Pantelidis, 2009).

Presence is a central concept in VEs, which can be described as "the perceptual illusion of non-mediation"(Lombard & Ditton, 1997), or the phenomenon where a person fails to perceive or acknowledge that a mediated experience is mediated. Presence can be divided into two categories: spatial presence which refers to the "the sense of being physically located somewhere" (IJsselsteijn, Ridder, Freeman, & Avons, 2000) and social presence which refers to "being with others" in a mediated environment (Heeter, 1992). Many factors have been suggested as possibly affecting the sense of presence, including media form factors (immersive technology), content factors and user characteristics (IJsselsteijn et al., 2000).

Depending on the technology used, VEs can be experienced with various levels or immersion and presence. Until recently immersive technologies were very expensive and thus not widely used. A disadvantage they have is that they can cause a feeling of discomfort to their users due to mismatch between user motion in the real and virtual environment (e.g. user is walking in the VE while standing still in reality). This discomfort is called Simulator Sickness and is similar to motion sickness, although less severe and of lower incidence. Common symptoms are eyestrain, headaches, dizziness, sweating, disorientation, vertigo, and nausea (Freina & Ott, 2015; Kennedy, Lane, Berbaum, & Lilienthal, 1993; Shaw et al., 2015). Nowadays there are commercial products like the Oculus Rift Head Mounted Display (HMD) that offer high immersion at an affordable price while minimizing the effects of Simulator Sickness (Freina & Ott, 2015). Higher immersion is not always more effective or appropriate for all applications. User experience and economic considerations may indicate desktop virtual reality as more suitable for many learning applications (Mellet-d'Huart, 2009).

Virtual Environments in culinary education

Culinary education is a form of vocational training which has been booming in the last years. Many students have entered culinary training because of the positive professional image of chefs created by the media (Hsu & Chien, 2015). Nevertheless, technological adaptation in the field has lagged behind that of other academic topics. However, culinary arts are slowly beginning to adopt ICT as a learning tool (Brown et al., 2013). Research indicates that both culinary educators and students would like more technology in their curriculum (Hsu & Chien, 2015; Mandabach, Harrington, VanLeeuwen, & Revelas, 2002).

The most researched ICT intervention in culinary education has to do with online training videos (Brown et al., 2013; Hsu & Chien, 2015). There are no studies regarding the design and evaluation of VEs for culinary arts. The aim of this study is to fill this gap in literature by designing, implementing and evaluating a VE for culinary education.

Literature Review

Because there are no studies regarding VEs in culinary education, the scope of the review was extended to also include other ICT tools in culinary education, as well as studies regarding VEs in vocational and adult education.

Hsu and Chien (2015) compared the performance of 100 high school students of a hospitality programme in Taiwan, in preparing two dishes (one basic and one advanced). The participants were assigned to two groups: the experimental group was trained using online video demonstrations with subtitles via an LMS, while the control group was trained using traditional face to face instruction. Their performance was evaluated by experienced chefs and the results indicated that the experimental group performed better on both dishes.

In a similar study Brown et al. (2013) compared the learning outcomes for 390 university students who were enrolled in an introductory cooking course, with two instructional delivery methods: online video and live class demonstration. The results indicated that both delivery methods produced similar student performance levels when individual and team tasks were considered together. However, students taught by the online delivery method had better group performance than students taught by the traditional method. The findings suggest that the online video method is effective in culinary arts education.

Feinstein and Parks (2002) reviewed the literature regarding simulations in the hospitality industry. Their review was targeted mainly to managers and decision-makers in the broader hospitality industry and not to culinary educators.

Moving on to studies regarding VEs in the broader vocational education, Borsci et al. (2016) compared three training experiences for a car service procedure. Sixty participants were randomly assigned to one of the following: (1) observational training through video instruction; (2) experiential training in a high immersion CAVE; and (3) experiential training through a portable 3D lower immersion interactive table. The researchers measured the learning outcomes, usability and workload of each system. Results showed that virtualy trained participants, can remember significantly better the correct execution of the steps compared to video trained trainees. No significant differences were identified between the experiential groups neither in terms of post training performances nor in terms of proficiency, despite differences in the interaction devices. This suggests that the more affordable lower immersion interactive table can be as effective as the more expensive higher immersion CAVE for the training of car service procedures.

Nordbo, Milne, Calvo and Allman-Farinelli (2015) explored how VEs can be used to understand more about people's food choices. They created the Virtual Food Court (VFC) to test whether policy-based interventions such as the "sugar tax" and "nutrition labelling" can to promote healthier food choices. Studies about the efficiency of such interventions are difficult in large retail settings. The objective of the study was to assess how accurately the Virtual Food Court (VFC), represents a real food court. The VFC used the Oculus Rift HMD and a gamepad for navigation. Twenty-seven participants were assigned in two conditions: a control with regular food-court prices, and an experimental condition with taxes on food and beverages. The researchers measured the perceived realism and usability of the environment. Results showed that participants were able to imagine doing their real-life food purchases in the VFC indicating that it is a good research tool for assessing people's food choices.

Shaw et al. (2015) created an exercise video game (excergame) with the aim to increase user motivation for exercise, fitness and reduce obesity levels. They evaluated its effectiveness using two levels of immersion: a standard pc monitor and the Oculus Rift HMD. The Oculus

Rift resulted in a slightly higher motivation, but no noticeable change in performance. The HMD was most effective for sedentary users.

The above literature review reveals that although VEs with various levels of immersion have been used and evaluated in vocational and adult training with positive results, there are no VEs for culinary education. The aim of this study is to design a VE for culinary education and evaluate it in terms of user experience with different levels of immersion.

Method

The Virtual environment

The "Virtual Chef" VE for culinary education was designed for the purpose of the study. It is the representation of the actual kitchen in which culinary students of a Private Institute of Vocational Training are trained. This allows for authentic learning in a familiar environment. The users of Virtual Chef can practice the execution of 50 recipes by collecting the necessary ingredients and utensils and using the appropriate cutting and cooking techniques. The VE incorporates gaming features (objectives, review, feedback), that contribute to better learning and reflection. More specifically, the user has to go through four distinct phases. The first phase is initialization, where he/she reads the instructions, inputs their name, chooses the level of difficulty (easy or hard) and selects a recipe to execute. At the end of this phase the user is presented with instructions on how to execute the selected recipe. Then they enter the collection phase where they must navigate in the virtual kitchen in order to collect the necessary ingredients and utensils from three different locations (Fridge, Dry Food, Utensils). When all the required items have been collected into their inventory, they enter the cooking phase. In this phase they are presented with a 2D screen with several icons. The left part of the screen contains the icons representing the previously collected ingredients and utensils, while the right part of the screen contains the icons representing the available cutting and cooking techniques. The user has to combine the appropriate ingredients, utensils and techniques in the correct order. Once all the necessary combinations are completed, the user enters the review phase where they can review the steps they have made, restart or terminate the application.

Design

The 3D virtual kitchen was modelled with Autodesk Maya και 3D Studio Max. The creation and processing of 2D images and icons was made with Adobe Photoshop. The final VE was created and programmed in Unity3D. Two versions were created, one with low immersion and one with high immersion. The low immersion version (Desktop) involved a standard LCD monitor, keyboard and mouse. The high immersion version involved an Oculus Rift DK2 HMD with head rotation tracking, a standard game controller and gaze control (based on "ProDigital VR No touch GUI" from Unity Asset Store).

Participants

A total of 24 undergraduate and graduate students of a Private Institute of Vocational Training participated in this study. They were specializing in either ICT or Culinary arts. Their ages ranged from 18 to 45 years (Mean=27.92, SD= 8.06) and most of them (87.5%) were males. Participants had no previous experience of the application and were randomly assigned into two groups: Desktop (n=12) and HMD (n=12). Each group consisted of equal number of ICT (n=6) or Culinary arts (n=6) students.

Instruments

User experience was evaluated by measuring five different user metrics: Time to execute a recipe, Spatial Presence, Usability, Workload and Simulator Sickness.
Time to execute a recipe was measured automatically by the VE in "minutes: seconds". All participants had to select the same recipe.
Presence was measured using the Temple Presence Inventory (TPI), a cross-media, multidimensional, well-validated tool (Lombard, Ditton, & Weinstein, 2009), which is based on 7-point Likert scales.
The usability of a system reflects the ease of learning and using it. It was measured using the System Usability Scale (SUS), a 10 item questionnaire that measures the overall perceived usability of a system in a range from 0 to 100 (Brooke, 1996). A score over 68-70 indicates that the usability of a system is above average or acceptable (Bangor, Kortum, & Miller, 2009; Nordbo et al., 2015).
User workload was measured using the NASA Task Load Index (TLX). It contains 6 items that measure mental demand, physical demand, temporal demand, performance, effort, and frustration. The overall TLX score ranges for 0 to 100, with lower scores indicating lower workload (Hart, 2006).
Simulator sickness was measured using Simulator Sickness Questionnaire (SSQ), a 16 item scale. SSQ provides three subscale scores concerning corresponding symptom clusters (Oculomotor, Disorientation and Nausea) as well as a total severity score. All scores have zero as their lowest level (no symptoms) and increase with increasing symptoms reported (Kennedy et al., 1993).

Procedure

Participants were brought in a classroom where they were briefly introduced to Virtual Chef VE. Participants of HMD group received extra instructions on how to wear and use the Oculus Rift, the game pad and gaze control. Then participants had to execute the same recipe, going through the four phases of Virtual Chef. After they completed the recipe, they filled an online questionnaire containing demographics questions and the scales regarding Presence, Usability, Workload and Simulator Sickness. They also had the option to write a free comment.

Data collection and statistical tools

The online questionnaire was created and administered with Google Forms. The responses were imported into SPSS 21 for statistical processing. Because the sample was rather small, non-parametric statistical tools were used. More specifically the Mann-Whitney U test was used to detect differences between groups.

Results

Table 1 presents the mean time (in minutes: seconds) required for the participants of each group and specialization to execute a specific recipe.
The mean time to complete a recipe was longer in the HMD group (Desktop: Mean=09:15, SD=02:24, HMD: Mean=14:53, SD=03:49) and this difference was statistically significant according to Mann Whitney U Test ($Z=-3.465$, $p=.001$). The differences between specializations in each group were not significant (Desktop: $Z=-.641$, $p=.522$, HMD: $Z=-.241$, $p=.810$).

Table 1. Time to execute a recipe

Interface	Specialization	N	Min	Max	Mean	SD
Desktop	ICT	6	06:05	13:57	08:50	02:53
	Culinary	6	07:25	11:57	09:40	02:00
HMD	ICT	6	11:00	22:27	14:38	04:14
	Culinary	6	10:49	21:03	15:08	03:44

Table 2 presents the mean Spatial Presence measured with TPI for the participants of each group and specialization.

Table 2. Spatial Presence (TPI)

Interface	Specialization	N	Min	Max	Mean	SD
Desktop	ICT	6	1.80	6.20	4.50	1.51
	Culinary	6	2.20	5.40	3.77	1.13
HMD	ICT	6	4.00	6.20	5.27	.78
	Culinary	6	2.40	5.00	3.63	1.04

The mean Spatial Presence was moderate for both groups (Desktop: Mean=4.13, SD=1.33, HMD: Mean=4.45, SD=1.22) and did not differ statistically according to Mann Whitney U Test (Z=-.579, p=.562). The difference between specializations was not significant for the desktop group (Z=-1.212, p=.226), but was significant for the HMD group (Z=-2.330, p=.020).
Table 3 presents the mean Usability score measured with SUS for the participants of each group and specialization.

Table 3. Usability (SUS)

Interface	Specialization	N	Min	Max	Mean	SD
Desktop	ICT	6	52.50	95.00	81.25	15,23
	Culinary	6	70.00	90.00	78.75	8,48
HMD	ICT	6	45.00	95.00	69.17	20,35
	Culinary	6	60.00	82.50	72.50	9,87

The mean usability score was higher in the Desktop group (Desktop: Mean=80.00, SD=11.82, HMD: Mean=70.83, SD=15.35) but this difference was not statistically significant according to Mann Whitney U Test (Z=-1.597, p=.110). The differences between specializations in each group were not significant (Desktop: Z=-.964, p=.335, HMD: Z=-.323, p=.747).
Table 4 presents the mean Workload score measured with NASA-TLX for the participants of each group and specialization.

Table 4. Workload (NASA-TLX)

Interface	Specialization	N	Min	Max	Mean	SD
Desktop	ICT	6	30.00	50.00	43.61	7.70
	Culinary	6	18.33	48.33	30.83	10.99
HMD	ICT	6	8.33	56.67	33.06	16.98
	Culinary	6	11.67	38.33	25.28	9.68

The mean workload score was higher in the Desktop group (Desktop: Mean=37.22, SD=11.24, HMD: Mean=29.17, SD=13.79) but this difference was not statistically significant according to Mann Whitney U Test (Z=-1.505, p=.132). The differences between specializations in each group were not significant (Desktop: Z=-1.935, p=.053, HMD: Z=-.884, p=.377).

Table 5 presents the mean Simulator Sickness score measured with SSQ (total score) for the participants of each group and specialization.

The mean Simulator Sickness score was much higher in the HMD group (Desktop: Mean=5.92, SD=8.80, HMD: Mean=48.31, SD=29.16) and this difference was statistically significant according to Mann Whitney U Test (Z=-3.688, p=.000). The differences between specializations in each group were not significant (Desktop: Z=-1.879, p=.060, HMD: Z=-1.444, p=.149).

Table 5. Simulator Sickness (SSQ)

Interface	Specialization	N	Min	Max	Mean	SD
Desktop	ICT	6	.00	26.18	10.60	10.42
	Culinary	6	.00	7.48	1.25	3.05
HMD	ICT	6	18.70	74.80	58.59	20.85
	Culinary	6	7.48	100.98	38.02	34.39

Discussion and conclusions

The aim of this study was to design a VE for culinary education and evaluate it in terms of user experience with two different levels of immersion: low (desktop) and high (HMD). Twenty-four students and graduates of a Private Institute of Vocational Training specializing in either ICT or Culinary arts participated in this study. Results showed no significant differences in terms of spatial presence, usability and workload between the two interfaces.

The time to complete a recipe was significantly longer in the HMD group. According to participants' free comments, this could be attributed the fact that the fonts were too small in the HMD screen and thus difficult to read. This indicates the need to create a different user interface with larger fonts and icons for the HMD version. Another issue that may have delayed HMD users was the gaze control. In order to select an icon, HMD users had to focus their gaze on the icon for 3 seconds, while desktop users could do the same with an instant mouse click.

Spatial Presence was moderate and did not differ between groups. This was rather unexpected since HMD is considered a high immersion interface that has the potential to produce higher levels of presence. The same and moderate levels of presence between groups could be attributed to the fact that only one out of the four phases of the cooking activity involved navigation in the 3D kitchen (collection phase). The other phases (initialization, cooking and review) involved a standard 2D interface.

Usability was acceptable (score above 70) in both groups and although the SUS score was considerably higher in the Desktop group the difference was not statistically significant.

The workload was relatively low and did not differ significantly between groups.

The mean total score of Simulator Sickness was significantly higher in the HMD group, a finding that is compatible with literature (Sharples, Cobb, Moody, & Wilson, 2008).

As an overall conclusion the desktop interface seems more appropriate for the Virtual Chef VE. The recipe takes less time to complete, it produces less simulator sickness and of course it is cheap and broadly available. It seems that the extra immersion does not benefit Virtual Chef in terms of user experience, maybe because it is not a pure 3D environment but it involves also 2D parts. A future extension of this study would be the investigation of the learning outcome of the VE with a larger sample of culinary students.

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