HAL
open science

Embodied edutainment experience in a museum: discovering glassblowing gestures "Savoir-verre": an interactive installation for informal learning deployed at "Musée des Arts et Métiers"

Alina Glushkova, Sotiris Manitsaris, Dimitrios Makrygiannis

To cite this version:

Alina Glushkova, Sotiris Manitsaris, Dimitrios Makrygiannis. Embodied edutainment experience in a museum: discovering glassblowing gestures "Savoir-verre": an interactive installation for informal learning deployed at "Musée des Arts et Métiers". International Conference in Multimodal Interaction, Oct 2023, Paris, France. hal-04323071

HAL Id: hal-04323071

https://minesparis-psl.hal.science/hal-04323071v1

Submitted on 5 Dec 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Embodied edutainment experience in a museum: discovering glass-blowing gestures

"Savoir-verre": an interactive installation for informal learning deployed at "Musée des Arts et Métiers"

FirstName Surname†
Department Name
Institution/University Name
City State Country
email@email.com

FirstName Surname
Department Name
Institution/University Name
City State Country
email@email.com

FirstName Surname
Department Name
Institution/University Name
City State Country
email@email.com

ABSTRACT

Current technological progress has provided innovative methods and tools for learning and discovering various aspects of manual professions. To valorize their artifacts and mostly the craft and know-how behind them, museums are more and more attracted by these innovative interactive technologies. In this paper, we present an interactive installation for embodied edutainment experience developed in the framework of the exhibition "savoir-verre" implemented at "Musée des Arts et Métiers" in Paris. This installation had a double goal: to augment and improve the entire museum visiting experience (entertainment) and at the same time to go deeper into craft discovery, to learn the basics of the expert postures/gestures (education). In front of the camera, that captured their motions, visitors were invited to imitate 3 gestures of an expert glass-blower and received real-time multimodal (visual and auditory) feedback, guiding the execution of the gestures. The quantitative analysis of user's motion data captured during the use of the installation highlights its positive effect on users' engagement, on their spatial and temporal performance, confirming the initial hypothesis that the multimodal real-time feedback can contribute to a better understanding and assimilation of expert gestures in glass blowing.

CCS CONCEPTS

• Interactive installation • Embodied edutainment in museum • Real-time feedback

KEYWORDS

Motion capture, learning by doing, traditional crafts, visual feedback, auditory feedback, real-time interaction

ACM Reference format:

FirstName Surname, FirstName Surname, and FirstName Surname. 2018. Insert Your Title Here: Insert Subtitle Here. In *Proceedings of ACM ICMI Conference (ICMI'23). ACM, New York, NY, USA, 4 pages.* https://doi.orgXXX

1 Introduction

In most cases, museums expose artifacts and objects and for a long time, the "don't touch" spirit dominated the visiting experience. Current technological progress made interactive technologies based on motion capture and artificial intelligence accessible to large public and started the transformation of a visit from a passive to an active process. Museums adopted these technologies and exploited their potential to attract the public and improve the visiting experience. As explained in [1] interactive installations are used with various objectives: first of all to facilitate immersion, stimulate curiosity, attract attention, and add an entertaining dimension by generating excitement. A systematic literature review [2] revealed that AR, VR, XR technologies are very promising and are preferred for on-site use. In [3] the "Move Your Body" installation improved the engagement of Science Museum visitors since it enabled people to explore large sets of data using interactive visualizations that users control with their own gestures and body movements. Embodied exploration has been also used to facilitate understanding and learning, beyond pure entertainment. In the Spanish Civil War museum [4] researchers used the physical world to interact with digital content by using AR projections and embodied enactment. Also, embodied interactive technologies are appropriate to inform and sensitize the public not only about the material dimension of the object exposed but also the intangible heritage beyond it, the know-how necessary for its creation [5]. For example, a mixed reality application has been developed to illustrate the making process of Cantonese porcelain while the user was scanning the object with a tablet/smartphone [6]. The qualitative analysis of this case study revealed that the embodied interaction here enables a better perception of pedagogical contents from multiple sources (video, audio, etc.) Another recent work, done in the framework of the EU-funded project MINGEI, underlines the benefits of immersive

technologies in discovering a traditional craft by combining 3D projections and animation of virtual humans [7].

2 Developing the interactive installation for informal learning of glass-blowing gestures

2.1 Technological and museographical set-up

The exhibition "Savoir-verre" organized from 10/2021 to 04/2022 at "Musée des Arts et Métiers" in Paris aimed to valorise the tangible and intangible aspects of a glass masterpiece: a carafe created by a brilliant glassmaker G. Bontemps [7]. To permit the visitor to physically play the role of a learner glass-blower a space was dedicated where a real glass maker workbench and blowing pipe were installed, various parts of the carafe were presented in dedicated showcases, and 3D projections were made on a video wall to augment the immersion effect [7]. An RGB-D camera was installed on the upper part of the screen. The visitor was invited by a visual message to sit on the bench, take the pipe and activate the installation by raising the right hand. Computers and speakers were hidden behind the showcases.

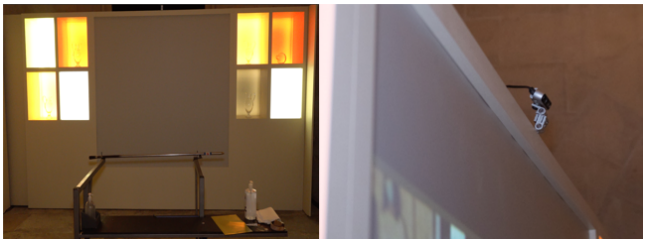

Figure 1: The glass bench, the showcases to present the carafe, and the camera used to track the user.

Videos of the expert Jean-Pierre Mateus from CERFAV, performing the 3 gestures (G1,G2,G3) for the creation of the carafe were then projected on a wall (fig.1, fig.2) and right after the user was invited to start imitating the gestures. In G1 the master turns the pipe, in G2 he uses pliers to form the neck and finally in G3 he stands up to blow the glass sphere. Real-time visual and auditory feedback artificially created and activated by the output of the user's kinematic performance evaluation module was provided to the user. The goal was to activate the learning-by-doing and imitation principles where the learner can continuously follow the gesture's example, try to reproduce it, and update his/her sensorimotor loop. A video illustrating the installation can be found on youtube[1].

2.2 User's spatial and temporal evaluation based on motion capture and Gesture Operational Modelling (GOM)

To evaluate user's spatial and temporal performance, kinematic deviation of user's joints (X and Y) from expert ones was calculated. For this, expert glassblower motions were first captured with various technologies such as wearable IMUs and cameras leading to the creation of a dataset [9]. Then expert skeleton was extracted from the videos by using the OpenPose framework [8] which detects body key points (or joints) on the RGB image and extracts a skeletal model together with the 2D positions of each body joint which is then normalized by using the neck as reference point.

However, in the framework of an informal learning and edutainment experience, a comparison between absolute values of expert and user wrists positions can't be used, because this would mean that a strict proximity of gestures should be achieved and this could be detrimental for the motivation of the user. The Gesture Operational Model (GOM) developed in [11]. was used to mathematically represent interdependencies between joints and to estimate the upper and lower bounds, which correspond to a static zone of tolerance to spatial variance, within which user's gesture can be considered acceptable integrating thus a certain degree of flexibility. More details on the calculation of these bounds can be found in [10] and [11]. The 2-dimensional Euclidean distance between the user's and expert's wrists was computed and a real-time control done to verify if this distance was inside or outside the acceptable margin.

In parallel a score was calculated where for each timeframe within the acceptable bounds a +1 point is added to reach 100 points. The experience passes automatically to the next gesture a) whenever the user reaches 100 points (in total approximately 20 sec of correct performance) or b) in case he/she doesn't reach the points within a time limit of 90 sec., defined empirically since each gesture is executed by the expert circularly until he/she judges that the goal has been achieved. It has been thus considered important to give the possibility to the user to perform multiple trials of the same gesture, continuously. A too short or long-time limit could be harmful to the engagement of the user as well as to the interpretation of the feedback.

2.3 Multimodal real-time feedback

To design the feedback the natural "in-person transmission" has been observed at CERFAV, France. First, "observation-based learning" is initiated where learner observed how does the expert perform the gestures. Then he/she is invited to reproduce and imitate them, activating thus the "learning-by-doing" principles, trying to embody the master's kinematic patterns, while receiving in parallel his/her comments and guidance. The edutainment experience was developed Inspired by this sensorimotor interaction.

[1] https://www.youtube.com/watch?v=_7GwbvxjHrc

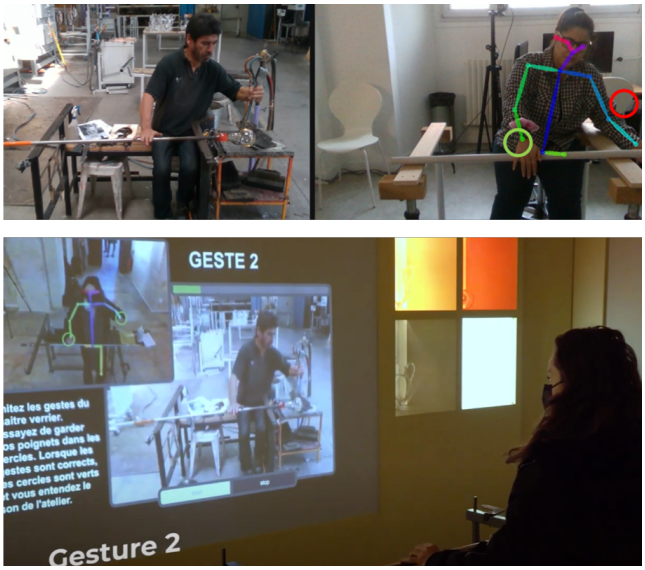

Figure 2: Example of visual feedback tested in the lab and the final interface in the image below.

First of all a video of the expert performing the 3 gestures was projected to give the possibility to the user to attentively observe the gestures to imitate. Then the output of the evaluation module described in 2.2 provided input for the activation of 3 different feedbacks by using 2 modalities, 2 visual feedbacks and 1 auditory: 1) **visual abstract concurrent** (continuous) **sensorimotor feedback** where the user could see himself in a video stream, as a mirror effect, juxtaposed with the video of the expert. The skeleton extraction was visualized to help the user better understand, "feel" and embody his/her wrists positions in space. Circles were continuously projected corresponding to the expert position and their radius represented the tolerance defined. A Color coding was used to indicate whenever the user deviated from the acceptable margin: the circles became red when the user was out and green where he/she was inside. This type of visual annotation contributes to the **knowledge of performance** according the typology of feedbacks [12] contrarily to another complementary technique where 2) **visual feedback** provides **knowledge of result.** Here it was given to the user through a horizontal green bar that visualized his/her progress score (the points collected up to 100). And 3) **auditory feedback in the form of a positive alarm** was implemented and activated whenever the deviation was within acceptable bounds and deactivated when it was not. Three metaphoric sounds (one for each gesture) inspired by the natural sounds of the glassblowing environment were mapped to each gesture.

3 Evaluation and results

3.1 User engagement

One of the goals of this installation was to positively affect the interest of visitors when discovering the glass-blowing craft. In total, the installation has been activated 1697 times. This number has been counted based on the triggering system deployed (mentioned in 2.1).

As presented in the table below, among these 1697 activations, the G1 has been performed 1099 times. The difference with the total number of activations could be due to various parameters such as the visitor not being willing to experiment either because he/she didn't have time to dedicate, or didn't want to touch the pipe for Covid-related reasons or other reasons.

Among these 1099 trials, 821 users also performed the G2. The difference between the number of persons who didn't try at all (- 598) and the ones who tried the G1 and then didn't continue to G2 has been considerably reduced (-278). The same tendency can be observed when the user passes from G2 to G3 since the number of G3 performances was reduced by only 87 trials. This means that the more the user advances in imitating the gestures the less he/she tends to give up the experience and the more he/she is motivated to reach the end. This can be also explained by the fact that the more the visitor interacts with the feedback the better he/she understands how it works and the more complete the feedback appropriation.

	# of trials	% of activations and trials
# of total activations	1697	100% of total activations
G1 trials	1099	64% of total activations
G2 trials	821	48% of total activations
G3 trials	734	43% of total activations
G1 successful trials	564	51% of G1 trials
G2 successful trials	589	72% of G2 trials
G3 successful trials	534	73% of G3 trials
G 1 and G 2, both successful trials	423	52% of G2 trials
G 1, G 2, and G 3 were all successful trials	345	47% of G3 trials

Table 1: activations and trials performed in the museum

3.2 Spatial performance

When looking at the spatial performance of users for G1, 564 trials out of 1099 (51%) have been successfully completed meaning that the error/deviation was acceptable (within the thresholds defined) within the time limit defined (90 sec). While continuing to G2 the users seem to better understand the general functioning of the interaction, they have a better ability to interpret the feedback since the percentage of successful trials in comparison to the G1 has augmented (589 out of 821 = 72%). The same phenomenon can be observed with the G3

where 73% of trials were successful. Progressively the users improve their spatial performance and reduce the deviation while they are advancing from G1 to G2 and G3.
It is also possible to observe that 423 trials out of 821 have been successfully completed for both G1 and G2, which corresponds to 52% of trials. This number represents the number of users who directly "caught" the idea of being guided by the feedback and correctly performed the first 2 gestures. For these users the interpretation of the feedback was intuitive and the guidance provided was beneficial for the performance. The percentage is slightly reduced when it comes to the total successful trials of the 3 gestures where 47% of trials were completed successfully. However, it means that almost half of the users managed to perform correctly the 3 gestures within the time limit defined.

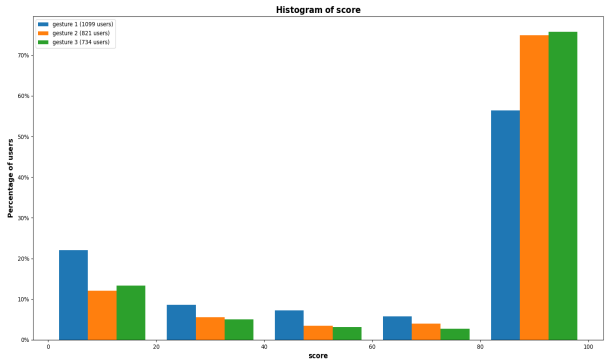

Figure 3: Percentage of users that achieved from 0 to 100 points (per group of 20 points) per gesture (blue G1, orange G2, green G3)

In the score histogram (Fig.3) the distribution of scores from 0 to 100 is presented by groups of 20 points, per gesture. In general, more than 60 % of trials for all gestures were successful illustrating that the feedback is meaningful and helpful. The best score was achieved by more than 70% of trials for G2 and G3. The G1 still has a lower percentage confirming that the G1, since it comes first, corresponds to a phase where the user learns how to interact and interpret the feedback.

3.3 Temporal performance

As explained in Section 2, a maximum time duration has been defined when the experience passes automatically to the next gesture. In the histogram below we can see the time duration of trials where all 3 gestures were completed (345 trials). it presents the percentage of users performing the 3 gestures with different durations from the shortest (20 sec.) to the longest (90 sec.). The best temporal performances, are located at the beginning of the horizontal axis. Almost 70% of users finished the G2 and G3 in less than 40s, unlike the G1 that only 30% of the users finished in less than 40s.

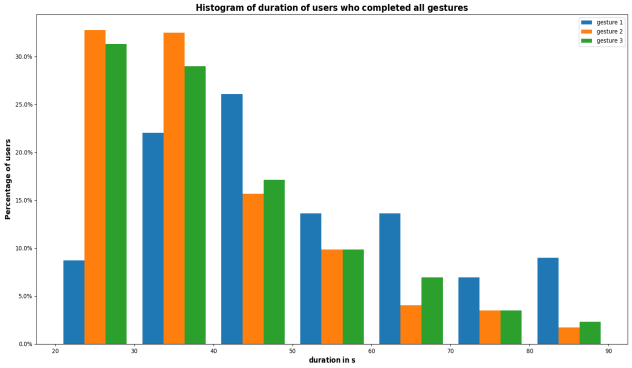

Figure 4: Proportion of users performing the 3 gestures with different durations from the shortest to the longest

These results show that the users probably needed some time to get used to the interaction mechanism and once this was achieved the majority managed to reach an almost optimal time of performance. Even for the G3 where the users needed to stand up and change their posture completely, their performance was slightly deteriorated in comparison to G2.

4. Discussion

In this work an embodied interactive installation was developed and deployed in a museum, confirming the initial hypothesis that the multimodal feedback arouses curiosity and permits the visitor to put himself for some minutes in a place of a craft master, while trying to physically imitate his gestures realizing thus the complexity of the tasks. The more the users have been engaged in the process of trying to imitate the gestures, the more motivated they were to complete the experience and to go until the end while progressively improving their capacity to interpret the feedback and reaching an optimal kinematic performance.
Embodied interactive systems have the potential to support informal human learning, which merits additional research. Finding the best sensorimotor feedback format for engagement and learning is challenging because it also takes into account factors like cognitive load, motor skill memorization, user interpretation abilities, etc. However, even outside of cultural settings like museums, the field of crafts suffers from a severe lack of interactive pedagogical tools that allow users to actively demonstrate the gestures they are trying to learn while also having them evaluated simultaneously by technological tools.

ACKNOWLEDGEMENTS

This work was supported by the EU Horizon 2020 Innovation Program and Grant No. XXX, XXX project. The authors would like to express their gratitude to the glass-blower Jean-Pierre Mateus, from CERFAV for the motion capturing sessions.

REFERENCES

[1] Eva Hornecker and Jacob Buur. 2006. Getting a grip on tangible interaction. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (2006). DOI:http://dx.doi.org/10.1145/1124772.1124838

[2] Vasileios Komianos. 2022. Immersive applications in museums: An analysis of the use of XR Technologies and the provided functionality based on Systematic Literature Review. *JOIV : International Journal on Informatics Visualization* 6, 1 (2022), 60. DOI:http://dx.doi.org/10.30630/joiv.6.1.708

[3] Milka Trajkova, A'aeshah Alhakamy, Francesco Cafaro, Rashmi Mallappa, and Sreekanth R. Kankara. 2020. Move your body: Engaging museum visitors with human-data interaction. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (2020). DOI:http://dx.doi.org/10.1145/3313831.3376186

[4] Marie-Monique Schaper, Maria Santos, Laura Malinverni, Juan Zerbini Berro, and Narcis Pares. 2018. Learning about the past through situatedness, embodied exploration and digital augmentation of Cultural Heritage Sites. *International Journal of Human-Computer Studies* 114 (2018), 36–50. DOI:http://dx.doi.org/10.1016/j.ijhcs.2018.01.003

[5] Marilena Alivizatou-Barakou et al. 2017. Intangible Cultural Heritage and new technologies: Challenges and opportunities for cultural preservation and development. *Mixed Reality and Gamification for Cultural Heritage*(2017), 129–158. DOI:http://dx.doi.org/10.1007/978-3-319-49607-8_5

[6] Peng Tan, Damian Hills, Yi Ji, and Kaiping Feng. 2020. Case study: Creating embodied interaction with learning intangible cultural heritage through webar. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (2020). DOI:http://dx.doi.org/10.1145/3334480.3375199

[7] Anne Laure Carre et al. 2022. Mixed-reality demonstration and training of glassblowing. *Heritage* 5, 1 (2022), 103–128. DOI:http://dx.doi.org/10.3390/heritage5010006

[8] Zhe Cao, Tomas Simon, Shih-En Wei, and Yaser Sheikh. 2017. Realtime multi-person 2D pose estimation using part affinity fields. *2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)* (2017), 7291–7299. DOI:http://dx.doi.org/10.1109/cvpr.2017.143

[9] Brenda Elizabeth Olivas-Padilla, Alina Glushkova, and Sotiris Manitsaris. 2023. Motion capture benchmark of real industrial tasks and traditional crafts for Human Movement Analysis. *IEEE Access* 11 (2023), 40075–40092. DOI:http://dx.doi.org/10.1109/access.2023.3269581

[10] Alina Glushkova, Dimitris Makrygiannis, and Sotiris Manitsaris. 2023. Interactive sensorimotor guidance for learning motor skills of a glass blower. *Culture and Computing* (2023), 29–43. DOI:http://dx.doi.org/10.1007/978-3-031-34732-0_3

[11] Sotiris Manitsaris, Gavriela Senteri, Dimitrios Makrygiannis, and Alina Glushkova. 2020. Human movement representation on multivariate time series for recognition of professional gestures and forecasting their trajectories. (May 2020). Retrieved July 20, 2023 from https://doi.org/10.3389/frobt.2020.00080

[12] Dhara A. Sharma, Mohamed Faisal Chevidikunnan, Fayaz Rahman Khan, and Riziq Allah Gaowgzeh. 2016. Effectiveness of knowledge of result and knowledge of performance in the learning of a skilled motor activity by healthy young adults. (May 2016). Retrieved July 20, 2023 from https://doi.org/10.1589/jpts.28.1482