

The motivational effects and educational affordance of serious games on the learning of Cantonese opera movements

The preservation of intangible cultural heritage (ICH) and the sustainability of an art form rely on the transmission of knowledge and continuous evolution in ways that can adapt to changing socio-cultural environments. This paper presents the development of a project that gamified the learning of Cantonese opera movements and evaluated its motivational effects and educational affordance. The serious game consists of a total of 30 foundation sets of Cantonese opera movements captured by a professional performer, which are challenged and scored against the player's movement through a motion-sensing camera. An evaluation was conducted by other Cantonese opera performers ($N = 4$), whose positive responses support the learning opportunities that could be afforded and its potential in stimulating learners' interest in Cantonese opera. Findings of this study implies the feasibility of applying digital game-based learning to the preservation of ICH.

Keywords: cultural heritage; Cantonese opera; motion capture; educational affordance; motivation

Introduction

Recent developments in information and communication technology have seen an increasing use of computational methods for the preservation of cultural heritage. Technological approaches, such as immersive media (Jin, Fan & Kadir, 2022), mobile technology (Vrettakis et al., 2019), digital storytelling (Psomadaki et al., 2019) and serious games (Liarokapis et al., 2017) are now common practices. These new media technologies make available interfaces for sensory inputs and haptic feedback, in the process revealing possibilities for cultural heritage preservation beyond more conventional approaches. Emerging trends in immersive media, such as virtual, augmented and mixed reality, have not only made engagement and outreach more accessible for anyone with a mobile or computation device, but also allowed individuals

to benefit from the stimulating effects brought about by the immersive gameplay experience (Cheng & Leung, 2020).

This paper presents the development of a serious game design for the preservation of Cantonese opera, an example of ICH recognised by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2009. While most ICH around the globe face sustainability challenges (Barthel-Bouchier, 2013), the difficulty of preserving Cantonese opera is multifaceted because of its deeply rooted oral traditions and apprenticeship system, the substitution and replacement of traditional leisure activities with ‘modern’ entertainment such as movies, and the negative perceptions of younger generations who find it outdated and old-fashioned (Cheng, 2018; Leung, 2015a; Leung & Leung, 2010). Attempts have been made to incorporate new media and technology as part of the revitalisation process of this particular art form (Cheng & Leung, 2020; Leung et al., 2018); the resulting positive feedback sheds light on the conceptual underpinnings of the current project. While the emerging practice of gamification and the associated pedagogical frameworks have proved their effectiveness in engaging the public with matters of cultural heritage (e.g. Cozza et al., 2021; Lazarinis et al., 2022; Plecher et al., 2020), applications concerned with traditional musical culture, such as Cantonese opera, are rare. To further the affordance of serious games and examine their potential within the context of the preservation of ICH, this paper presents the design and evaluation of a serious game for learning Cantonese opera movements through motion capture. Specifically, it focuses on martial arts movements, in which human-computer interaction (HCI) plays an important role in the areas of system design and implementation.

Background

Cantonese opera and martial arts movements

Cantonese opera is one of the most representative Chinese opera genres, particularly in Guangdong and Guangxi Provinces where Cantonese is the local dialect (Chan, 1991). It is a form of traditional theatre art originally performed in ritual contexts, and comprises various elements such as music, dance, martial arts, acrobatics, costume, makeup and literature. Similar to other Chinese opera genres, such as Peking opera and Kun opera, actors and actresses have to sing, recite, act and fight on stage. In order to become a professional Cantonese opera artist, one has to be familiar with the four skills of singing, acting / movement, speech delivery and martial / gymnastic skills (Leung, 2015b, 2020). Learning the genre via the conventional apprenticeship route requires full-time training from a young age in order to develop the necessary skills. This may not be suitable for the modern world, where children are required to attend school until their teenage years. This is just one of the many challenges facing Cantonese opera in relation to its transmission and sustainability.

Movement is a critical part of the Cantonese opera skill set that the performer has to learn and maintain. In addition to direct, on-stage contact, such as through fighting, actors and actresses have to engage in many indirect, abstract movements specific to Chinese opera (Siu & Lovrick, 2014). These movements are usually symbolic and metaphoric, requiring the professional craftsmanship and artistry of the performer (Leung, 2020). For example, while riding a horse can be represented by holding and waving a horsewhip, the prestige and power of a general might be achieved via the metaphor of shaking a pheasant's tails on a helmet. Similarly, the use of mime is often employed as a means of suggesting actions, such as opening and closing a door. Professional and experienced practitioners are able to create their own versions of

movements as a means of developing an existing abstract scene, in the process formulating their own styles. Characteristics such as these make the transmission of Cantonese opera through systematic training and assessment a challenging proposition for new learners.

Serious games

The notion of serious games was first coined by Abt (1970), who defined them as games with ‘an explicit and carefully thought-out educational purpose ... not intended to be played primarily for amusement’ (p.9). Initially flourishing alongside the technological advancements emerging around the turn of the millennium, the trend of video games gave rise to serious games; growing rapidly in both depth and breadth, these have since gone far beyond the provision of edutainment, to the point where applications are now being utilised in contexts as varied as military training (DeFalco et al., 2018), healthcare (Ahmad et al., 2022), environmental protection (Csoknyai et al., 2019), and sports and exercise (Papastergiou et al., 2021). Addressing the motivational effects of games for educational purposes, Prensky (2001) proposed digital game-based learning as an approach that had the potential to simultaneously synergise and maintain a balance between interactive entertainment and serious learning. Since this notion was coined, digital game-based learning, which attempts to realise the idea of intrinsic motivation, whereby learners can be self-determined and self-motivated through the successful achievement of tasks that are interesting and fit their abilities (Gee, 2007), has provided the conceptual underpinnings and design, implementation and research frameworks for many projects (e.g., Papastergiou, 2009; Yang, Quadir & Chen, 2019; Zou et al., 2021).

Educational affordance

If digital games have the potential to stimulate learners' interest in subjects that they might not otherwise engage with, the next question becomes one of what these games might offer within the educational context. Gibson (1977) proposed the theory of affordance, which refers to the relationship between the properties of objects and their characteristics in ways that enable interactions to take place between an object and its user. Antonenko, Dawson and Sahay (2017) furthered the theory by illustrating that the possibilities for action that are latent in an object are dependent on the capabilities of the users. This theory was subsequently examined in the educational context by Kirschner (2002), who defined educational affordances as those characteristics of an artefact which determine whether and how particular forms of learning behaviour can take place. Educational affordance can be applied to improve students' learning by examining opportunities for interaction with the tool; in this case, serious games for learning Cantonese opera movements.

Related works

Using serious games for public engagement and the acquisition of cultural heritage has grown rapidly in recent decades as a result of the increasing accessibility of immersive technologies and ubiquitous computing. These applications make use of the stimulating effects afforded by games in order to raise learners' cultural awareness through historical reconstructions in the digital medium (Mortara et al., 2014). Plecher et al. (2020) designed a serious game that enhanced users' understanding of Egyptian hieroglyphs, one of the earliest-developed scripts in human history. Results from a questionnaire survey with the players revealed the stimulating effects for learners with little to no prior interest in the subject matter. Laiti et al. (2020) conducted a study to

explore how game jamming, a rapid collaborative game development format, could be appropriated for the purposes of revitalising ICH. They adopted an ethnographic approach including participatory observation, interviews and content analysis to investigate a game jamming event in Finland themed with the local indigenous culture, and concluded that game jamming as a cultural practice can be appropriated for the purpose of sustaining ICH. Huang and Huang (2013) developed a serious game about the cultural and life history of Taiwan's indigenous people; the results of their evaluations revealed the positive benefits of enhancing school children's learning motivation and performance. Far from being unique, the number of serious gaming design projects has continued to increase over the past two decades.

Recent years have also seen a rapid development in HCI and multimodal user interfaces for serious games and virtual environments, expanding the breadth of opportunities for simulation and training (Liarokapis, von Mammen & Vourvopoulos, 2021). Tanaka et al. (2010) produced a multimodal digital archive and reproduction of world cultural heritage 'Gion Festival in Kyoto'. Modelled with Geographical Information System (GIS) and VR technologies, the production makes available high-defined contents with visual, sonic and haptic artefacts for an interactive and immersive viewing experience. Reflecting on the experience of serious game designs for the transmission of specific ICH expressions, including singing, dancing, craftsmanship and music composition, Dagnino et al. (2015) addressed the importance of engaging with expertise in the field in order to achieve accurate design and successful system implementation. Chen and Chen (2014) archived the ICH of the Quanzhou breast-clapping dance through motion capture and 3D modelling. They made use of Vicon optical motion capture system to record the traditional dance and then representing it virtually through building a 3D avatar model. The motion capture system they adopted

is similar to that of the present project, which produces high-quality and accurate motion data suitable for digital archiving and simulation.

Methodology

Implementation of the gaming design was a two-fold process: (1) data acquisition of authentic Cantonese opera movements from a professional performer and the visualisation of the movements through 3D avatar modelling; and (2) design and implementation of the serious game.

Capturing and modelling of the Cantonese opera movements

The remodelling of authentic movements in traditional arts, such as folk dances and martial arts, is a difficult task, since they are ‘susceptible to the performer’s mentality and body type’ (Hajdin et.al, 2018, p. 248). This is also the case in Cantonese opera, in the sense that professional performers may have their own stylistic movements for the same abstract scene (Leung, 2020). On the other hand, although serious games emphasise the stimulating effects afforded by the gameplay experience, capturing highly accurate Cantonese opera movements is important in order to safeguard the transmission of the genre as an ICH. To ensure a high level of accuracy, the development team made use of Rokoko Smartsuit Pro, a high-end motion capture system with depth-sensing and human motion recognition technologies. Consisting of a smartsuit with 19 sensors and a pair of smart gloves with 7 sensors, the system allows for the captured movements to be streamed to its bundled software for visualisation with a custom 3D avatar (Figure 1). Standard procedures for setting up the smartsuit, such as aligning the system figures with the performer’s data, e.g., height, shoulder width, and the lengths of upper and lower arms, legs and feet, as well as calibrating the posture with a T-pose, were conducted before the motion capture took place (Figure 2).



Figure 1. 3D avatar that models the Cantonese opera movements



Figure 2. Calibrating the posture with the motion capture smartsuit

A total of 30 foundation sets of Cantonese opera movements, i.e. standard gestures within the genre that are considered suitable for beginners were selected and recordings made of a professional performer wearing the motion capture suit. Each movement set was repeated and recorded several times in order to prevent random

errors from occurring and ensure the performer was familiar and comfortable with the smartsuit. The raw motion data were noise-filtered and fine-tuned by the bundled software, resulting in a truthful representation of the movements. A 3D modelling avatar, designed as the virtual character capable of demonstrating the movements faultlessly, was then exported as a prefab for the gaming design.

Gaming design

The gaming design was guided by the Computerised Kinetic Chain Assessment and Learning System (CKCALS), which places the learner at the centre of the design process (Leung et al., 2018). It comprises a scoring system with mechanisms for quantitative and qualitative feedback, video playback of the standard movement from the professional performer, and the motion capture unit that record the body movement of the learner for further analysis. Ground on the theoretical framework of assessment for learning, the CKCALS protocol provides individualised immediate feedback information for the self-assessment and improvement of Cantonese opera learners at the beginning stage. It provides a flexible learning environment whereby the learner can manage his or her practices to suit the learning schedule and pace.

The 30 Cantonese opera movement sets captured from the professional performer were categorised into different levels, the players being encouraged to try the easier and shorter movement sets first in order to familiarise themselves with the user interface and the motion capture system before moving on to the more challenging longer ones. Players are guided towards choosing between two modes – ‘New Play’ and ‘Challenger’ – from the start menu when they engage in the serious game. The ‘New Play’ mode is designed for beginners who have no or very little knowledge of Cantonese opera. It provides step-by-step explanations and demonstrations of

movement sets without the motion capture and assessment elements. Players who already have some familiarity with Cantonese opera movements can opt for the ‘Challenger’ mode. Choosing from different levels of difficulty, their motions are captured and displayed as skeletons and shadows in real-time, together with the demonstration by the 3D avatar, so that they can imitate the standard movements during gameplay (Figure 3). An assessment report is generated after each challenge, which details the assessment results (rated as ‘excellent’, ‘good’, satisfactory’, ‘sufficient’, or ‘to be improved’) for each joint and position. Overall comments and suggestions are provided for the players so that they are able to improve their performance, followed by the option to try again or choose another challenge. Players can recalibrate the Kinect system if they discover any inaccuracies in the display of movements by choosing the configuration page in the start menu.

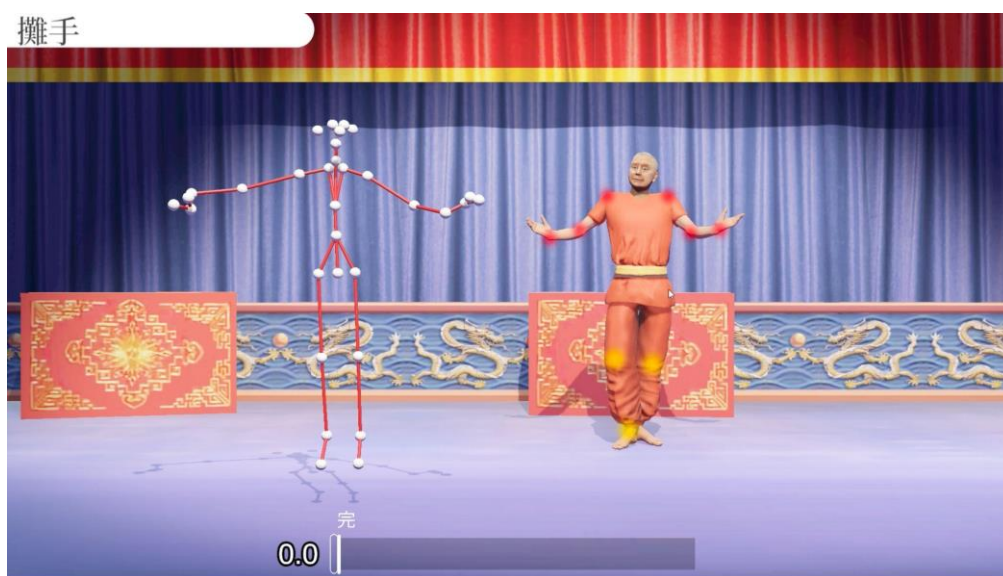


Figure 3. User interface during the gameplay

Gaming Implementation

The serious game was developed in Unity, a cross-platform game engine. Since motion capture suits are costly and difficult to set up, the serious game made use of another

motion capture system, Microsoft Azure Kinect Developer Kit (hereafter, Kinect), as an affordable and accessible client-side solution. Kinect captures motions through its camera and depth sensor, producing a 32-joint skeletal model in which there is a hierarchical flow from the centre of the body to the extremities. However, since the number of joints and the vertex positions are different between the two motion capture systems, previously recorded motion capture data in the Rokoko Smartsuit Pro had to be adapted to match the trajectory of each limb in Kinect. Since the smartsuit represents motion data in 3D vectors, these coordinates had to be converted to 2D during the batch processing stage. In general, a five-degree discrepancy for any intersecting angles was allowed between the two motion capture systems.

Evaluation

A pilot study with four Cantonese opera performers was conducted in order to evaluate the motivational effects and examine the educational affordances of the serious game developed in this project. Employing a qualitative approach through expert interviews (Döringer, 2021), in the process seeking to go beyond pure description so as to gain an in-depth understanding of the phenomenon (Grant & Wall, 2009), the participants were invited to play the serious game as guided by the research team, after which they took part in semi-structured interviews. This approach was particularly beneficial to the current study, as the participants were more knowledgeable in their particular area of expertise than the researcher. It also provided room for both the researcher and the respondents to converse in a more improvisatory manner; the former about the project as a whole and the latter about issues of interest or importance to themselves (Leedy & Ormrod, 2015).

Participants and sampling

Purposive sampling was adopted as the approach for the selection of participants (Palys, 2008), all of whom were performers with at least ten years' experience in Cantonese opera performance and who also played video games in their leisure time. They were experienced in teaching Cantonese opera to school students as extra-curricular activities or within the formal curriculum, and often provide guidance to apprentice in various Cantonese opera troupes. Although not as experienced as the individual whose movements were recorded as the game's benchmark standard, the participants selected for this study were nevertheless able to take advantage of the game's pedagogical potential and evaluate its limitations, through the detailed contextualisation of what they found stimulating based on their gaming experiences. Table 1 shows the participants' demographic information.

Table 1. Demographic information of the participants

[Table 1 here]

Procedure

Targeted Cantonese opera performers were invited by a member of the research team with strong Cantonese opera community connections to participate in the study through referral by professional and amateur performers. An official invitation was sent to the participants asking for their consent to participate in this study, and an appropriate date, time and venue arranged. During the evaluation session, which lasted for 60 minutes, participants were firstly guide-walked through the tutorials before tackling the 30 Cantonese opera foundation movement sets in the 'Challenger' mode for 40 minutes. One of the research team members accompanied the performer throughout the session in order to sort out any technical issues or concerns they might have during the

gameplay. A semi-structured interview, which lasted for approximately 20 minutes, and which was voice-recorded on the agreement of the participants, followed. Once all the interviews had been transcribed for the purposes of data analysis, the transcripts were sent back to the participants for double-checking.

Semi-structured interviews

Participants were invited to take part in semi-structured interviews on a one-to-one basis, their purpose being to follow up on the gameplay experience and evaluate the serious game in terms of its educational affordance and motivational effects. Questions to be asked, therefore, centred around the themes of user experience, level design, learning curves, accuracy of assessment, balance of fun and learning, and pedagogical issues in the educational context. The following series of open-ended questions guided each interview.

- (1) How was the actual gaming experience different from your expectations?
- (2) How accurate did you find the motion tracking assessment results of the game?
- (3) Did you find the game easy to use? Which parts did you find difficult or unclear?
- (4) What could a beginner in Cantonese opera learn through playing this game?
- (5) What kind of movements can or cannot be effectively learnt through this kind of system?
- (6) In which situation or context do you think this game would be useful?
- (7) How well does this game engage beginners to learn Cantonese opera?
- (8) To what extent do you think this game is effective and successful in terms of learning and motivating beginners?

- (9) What could be further improved in order for this game to be more effective in engaging beginners to learn Cantonese opera?
- (10) How would you compare this game's learning effectiveness with conventional learning approaches in Cantonese opera?

Data analysis

Open coding was used to analyse the qualitative data (Cohen, Manion & Morrison, 2011). Each line, sentence and paragraph was carefully coded, followed by the compilation of a set of recurring 'themes' by literally interpreting the text as guided by the scope of the study. Any coding discrepancies were reconciled through discussions among the research team.

Findings

Gaming design

When asked about the overall gameplay experience, the participants responded that the serious game made available interactivity through body movement in ways that gamified the learning process. They considered it suitable for beginners, who could learn through playing while referencing professional performers' standards.

This game allows the beginners to play and have fun, while at the same time learn the [Cantonese opera] movements subconsciously. (Participant A)

Because of the presence of the avatar and the interactivity involved, we as players could learn through imitating professional performer's movement. (Participant C)

Although the different difficulty levels served to challenge them, it was pointed out by the participants that some of the movement sets were too lengthy, resulting in a disproportionately steep learning curve.

I found it challenging with the level of difficulties made available in this gaming software. (Participant B)

Some simple movement sets are easy to follow as they only consist of one or two steps, which contrasts with some other movement sets which could be complicated and speedy. (Participant D)

It is better to split the lengthy movement sets to shorter ones and slow it down if necessary. If one has to learn the whole movement set in a go, s/he may forget some of the steps. (Participant C)

The participants also suggested some room for improvement in terms of gaming design. They emphasised the importance of pulse and musical accompaniment in Cantonese opera movements, both of which could reinforce the immersive nature of the gameplay.

Cantonese opera movement is best accompanied by music. I think the gaming design could simulate the environment of a theatre performance which includes the background music from the percussion group. (Participant B)

Since some of the movements require turning around that the player could not reference from the avatar at a moment, it is better to give the beats and pulses for them to follow easier. (Participant A)

Assessment

Participants expressed their expectations with regard to the assessment functions of the serious game, especially the report as a means of providing players with feedback for further improvement.

The gaming software is able to provide immediate feedback for the player's performance in detail from one step to another, specifying the marks for different parts of the body. (Participant A)

They compared the feedback provided by this serious game with that from teachers in a conventional setting.

This gaming software could provide immediate feedback, yet it is not as specific as feedback from teachers who would be able to figure out particularly how much higher should I raise my knee, for example. I think this is the main difference between learning through this game and conventionally from a teacher. (Participant C)

One of the participants mentioned the issue of standardisation in Cantonese opera. This was felt to be one of the fundamental issues in terms of assessing the movements, as well as the degree to which it formed the design of the assessment mechanism, in the serious game.

If there are ten Cantonese opera experts, there may be ten versions of the same movement set because they could have their own performing styles and acting patterns... therefore learners may have slightly different movements learning from different teachers. (Participant D)

Inaccuracy was the main issue pointed out by the participants. Some mentioned that the gaming software failed to match their speed, while others thought that movements featuring big leaps led to the misplacements of joints in the skeletal model.

I think the software seems unable to follow my body movements in some of the tasks. (Participant C)

Sometimes the system is inaccurate to assess my body movements if the task involves leaps, such as walking up and down the stairs. (Participant B)

Simple movement sets are fine. Yet the sensor seems to fail to capture my body movements for some tasks with speedy movements and leap actions, such as jumping and whole-body movement from one side to another. (Participant D)

Learning motivation

Apart from the stimulating effects brought about by challenging the movement tasks from one level to another, the participants also mentioned other gameplay elements that would enhance learners' sense of motivation.

This software allows novices to play as a video game while at the same time learning those [Cantonese opera] movements. I guess this is how they get motivated to learn. (Participant A)

I think whether the players could persist depends on the perceived improvement through the assessment system. If their marks are ascending, they will feel like improving and so keep practising for higher marks. (Participant B)

The participants suggested that the gameplay experience could motivate those students who may be interested in Cantonese opera to give it a try.

Those who have an interest in Cantonese opera but not the practising process may give their first try to learn those movements. (Participant B)

[The serious game] is suitable for beginners to learn and practice since they may find it interesting to play with. (Participant A)

One participant pointed out that as a traditional art form, Cantonese opera can sound old-fashioned to children. This serious game, with its use of an animated avatar and gameplay elements, might serve to change that perception.

Conventional learning is not as attractive as innovative approaches such as gamification. This software demonstrates the new learning style to learners, particularly for kids who are interested in the animated avatar. Moreover, the kids can practise by themselves in front of the computer screen rather than other people that may feel shy doing so. (Participant D)

Educational affordance

The participants agreed that the serious game was a viable learning tool for beginners, especially with its stimulating effects through gameplay.

This is a good learning and practising tool for novices or those who have never learned about Cantonese opera before. (Participant B)

I think this gaming software is more approachable to young learners, who could practise and learn basic knowledge and skills through this gaming software. (Participant C)

In addition to the motivational effects on beginners, the participants also mentioned that the serious game could also serve as a practising tool for more experienced Cantonese opera learners.

The gaming software could assess the performance when one is practising on his/her own. Since there is assessment and feedback, learners should be able to reflect on their performance for further improvement. (Participant A)

I may sometimes forget some steps of a movement set, and I would be afraid to be blamed by my mentor for the wrong movements or posture. Therefore, this game could be a good reference for me to practise in my leisure time. (Participant D)

Some skills, such as balancing, could be well developed through this gaming software. (Participant B)

Other than body movements, the participants pointed out some concepts and knowledge associated with the movements that could also be learnt through the serious game.

I think beginners could learn some basic knowledge about Cantonese opera as well through interacting with the gaming software and practising the movements. (Participant C)

I think they can learn some of the terminologies and underlying concepts of Cantonese opera through associating the vocabularies with the movement sets that they are practising with. (Participant A)

The potential of the serious game for self-directed learning was mentioned by one of the participants, who provided various thoughts about how it could be applied to different learning contexts.

This gaming software could cultivate students' self-directed learning, who could practise on their own during their leisure time. While it is difficult to monitor their performance from time to time, the gaming software could be helpful for learners to monitor their own performance. (Participant B)

Another participant had a different view, stressing that learners should learn to negotiate basic skills before practising with the serious game.

I think one should learn the fundamental skill with your teacher first before using the gaming software. Basic knowledge skills are important to beginners. I do not recommend beginners to use it as self-directed learning without sufficient skills and knowledge. (Participant D)

While participants provided many positive comments on its potential, they also pointed out the pedagogical limitations of the serious game. They argued that further training was needed if one wanted to become a professional performer.

I think this gaming software is more for daily practice of fundamental movements. It will not develop our skills to become professional performing on stage. (Participant B)

Some movement sets included a lot of abstract actions that may not be understood by users only through playing the game... riding horse is one of them. Students can understand the movement of riding a horse in daily life, but it is not easy to conceptualise in the virtual environment. (Participant A)

Take an example of the mounting and dismounting from a horse, the hands of the actor are supposed to grip the saddle, but could hardly be shown up on the screen. Most Cantonese opera body movements are abstract and therefore, advanced skills need to be developed otherwise. (Participant D)

This gaming software is good for practising movements. However, there are also drama and emotional expressions involved in Cantonese opera, which needs to be understood and trained otherwise from teachers. (Participant C)

When asked about the potential for transposing the serious game into school settings, the participants responded with positive feedback and shared their views on how it might be best incorporated.

I think it is possible to be incorporated in schools. The most important step for teaching Cantonese opera in schools is to motivate the students. The gaming software provided a solution for them to practise on their own once they have learnt a new movement set. (Participant B)

There could be synergy between conventional learning and innovative learning approaches, such as games. In this case, the gaming software could provide basic training for learners, while some complicated movements set could be guided and trained by the teachers. (Participant C)

Discussion

Responses from the participants revealed the potential of the serious game for learning Cantonese opera movements. In particular, they pointed out its affordance when applied to the educational context, the synergy of the motivational effects with gameplay elements, and the room for improvement in terms of assessment and gaming design. The use of motion capture as gaming control in HCI is still in the emergent stage. It provides game users with a novel gameplay experience, especially with a subject considered outdated and old-fashioned (Leung & Leung, 2010). Findings of the evaluation provide preliminary evidence supporting the synergy between the

interactivity stemmed from the motion capture element and the stimulating effects of the game to stimulate learning among the younger generation, thereby shedding light on the application of related technologies for the transmission of traditional arts and the preservation of ICH.

Results from the expert interviews confirmed the motivational effects of gameplay experience and immersive media on the subject matter, a finding consistent with those from a previous project by the same research team (Cheng & Leung, 2020) and other scholarly works on Chinese opera, traditional Chinese arts, and Taiwanese indigenous culture (Huang & Huang, 2013; Jin, Fan & Kadir, 2022; Zhou & Mudur, 2007). The serious game in this instance is able to engage beginners or people who may not be aware of Cantonese opera through the process of gamification, in the process helping to overcome one of the biggest hurdles for the transmission of ICH (Ismail, Masron & Ahmad, 2014). The transferability of affordance to educational contexts and the preservation of other ICH through synergies with technological approaches, such as digitalisation and the revitalisation of different forms of cultural heritage, are more advantages in its favour.

Accuracy of assessment is another major issue in gaming design. It not only ensures that the feedback is relevant to the players' performance, thereby leading to their continuous engagement, but also safeguards the standardisation and authenticity of the ICH that is being preserved. While the provision of an accurate assessment mechanism would appear to be basic to the development of any gaming software or learning systems, the involvement of emerging technologies has made the task difficult to achieve. As the participants pointed out, one of reasons for the assessment inaccuracies could be the result of limitations of the hardware and software design. There are also considerations in the cost effectiveness and feasibility issue for further

applications in the schooling context to bear in mind, which explains why the low-cost Kinect system was used on the client side while the pricier but more accurate motion capture smartsuit was employed during the modelling stage. All these considerations contribute to the design of a serious game's accurate assessment mechanism. Some improvements to the development process are already being adopted, such as closer involvement of the relevant expertise, leading to a more accurate system design (Dagnino et al., 2015); as in this evaluative study, the participant pointed out the need to incorporate music accompaniment into the gaming design, a factor that had not previously been considered by the development team. Aside from the standard inputs of time, resources and effort, careful consideration and continuous reflection at every stage of the design process are necessary for the quality development of a serious game.

Findings from the evaluations reflect the multifaceted affordance of serious games within the educational context. While beginner motivation was the key aim, the game can also serve as a practise tool for experienced learners, making available the understanding of basic concepts and knowledge associated with the movements, and as a self-directed learning tool framed by digital game-based learning. In addition to the debatable timing of the introduction of this self-directed learning tool, the participants also revealed the limitations of the serious game. These included its inability to teach advanced skills, shortcomings of the hardware and software technology, the absence of abstract ideas and emotional expression training, and the lack of catering to and development of personal styles. Some of these are common to the list of familiar authenticity and ethical issues within the realm of the digitisation of cultural heritage (Manžuch, 2017), while others are more specific to Cantonese opera and to ICH in general. While serious games and other technological approaches have the potential to safeguard the originality and integrity of ICH, ecological and developmental

considerations are essential to the sustainable growth of any design and its implementation. The early involvement of expertise in the design process is one feasible way of ensuring that any interdisciplinary product is both sustainable and authentic to the sector for which it is intended (Cheng & Leong, 2017).

The participants had positive views on the applications of the serious game within the schooling context, one of the long-term goals of the research and development team. The school environment is undoubtedly a good place for young people to acquire new, teacher-guided skills. Supporting and facilitating students' self-directed learning through the use of the serious game, supplemental knowledge, including but not limited to emotional expression, history, abstract imagination, and the more advanced skills in Cantonese opera, can also be incorporated. Previous studies have detailed similarly successful efforts in teaching Cantonese opera in schools (Leung & Leung, 2010); it is anticipated that, with the motivational effects of gameplay and the novel experiences with emerging HCI afforded by serious games, the transmission of Cantonese opera will emerge as one of the leading examples of ICH preservation through gamification.

Conclusion

This paper presented the development of a serious game for the learning of Cantonese opera movements that employed motion capture as the HCI, and evaluated its motivational effects and educational affordance through expert interviews. Comments from the experts were positive, who also provided valuable feedback for further improvement of the gaming design, along with suggesting some possible pathways for its application within the schooling context. To tackle the problem of 'discontinuity of inheritance' in Cantonese opera and the broader traditional arts (Leung, 2020, p. 146), innovative pedagogical approaches, combined with the involvement of emerging

technologies, present a viable solution for the sustainability and preservation of ICH.

In addition to the shortcomings of the gaming software mentioned by the participants, the research and development team acknowledge that there are several important limitations relating to the gaming design and its evaluation: since it was a pilot study, the end users' perspective was not assessed; as a deliverable of the iterative development process, the assessment logistics and user interface elements need to be fine-tuned based on the feedback from professional performers and other sources; and as part of a project aimed at the transmission of Cantonese opera, further public engagement should be implemented in order to achieve the overarching goal. Future work would therefore need to employ user-based evaluation on the merits of the learning and gameplay experiences and the fine-tuning of the game design from the most likely end users, i.e. school students (Nielsen, 1993), while storytelling and narrative elements, making the game more interactive, might also require integration within the overall process.

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