Online Dance Lesson Support System Using Flipped Classroom

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Abstract. Contemporary online lessons that use web-conferencing systems suffer from several issues, mainly because instructors engage in the same type of instruction as they do in conventional offline lessons. For example, it might be difficult for learners to grasp three-dimensional movements. Teaching through a video displayed on a screen is also limited, as opposed to teaching through physical bodies and showing movements in person. In addition, it is difficult for the instructors to teach one person at a time during a lesson with many students. This study proposes an online dance lesson support system that enables instructors to remotely but effectively teach multiple learners. We initially focus on the framework of online dance lessons and subsequently propose a lesson style that applies to flipped classrooms. We aim to provide a new lesson style for on-demand lessons and real-time lessons using deep learning techniques.

Keywords: training · dance lesson · flipped classroom · online.

1 Introduction

Although the development of information technology has benefitted intellectual labor, telecommunications, and digital content dissemination, it has reduced the amount of physical activity in people's daily lives and proliferated health problems caused by inactivity. In modern society, the lack of exercise needs to be compensated for by incorporating sports and exercise into everyday life to maintain normal bodily functions. Moderate exercise is also accompanied by a sense of exhilaration and can improve mental health. Spaces where everyone can enjoy exercising to maintain a healthy state of mind and body, such as fitness gyms, are crucial in modern society.

During the COVID-19 epidemic, demand for spaces where people can gather shifted from the physical world to the virtual world. For example, the closure of fitness gyms offering dance and other exercises opened opportunities for online lessons using web conferencing systems, such as Zoom. However, current online lessons frequently provide identical instruction to that of conventional offline

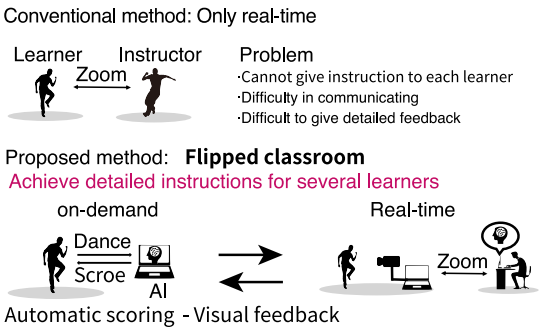

Fig. 1. Proposed online dance lesson applying flipped classroom.

lessons using an unmodified web conferencing system, causing diverse problems. For example, compared to instructions that use the physical body to show movements in person, instruction via video on a PC or other display makes it difficult to grasp three-dimensional movements and limits the methods of instruction. It is also difficult for instructors to instruct one person at a time in a large group lesson. Therefore, this study proposed an online dance lesson support system that enables instructors to remotely but effectively teach multiple learners. This study initially focuses on the framework of online dance lessons and thereafter proposes a lesson style that applies to flipped classrooms.

In particular, this study focuses on the flipped classroom as the basis of the framework. A flipped classroom is an educational method wherein learners work individually before the class on basic learning such as explanatory lectures, and engage with the instructor during the class on learning that is necessary for the retention of knowledge and development of application skills such as tutorials and project learning [2]. In conventional face-to-face and online dance lessons, "learning" (acquisition of individual movements) and "development/exercise" (acquisition and refinement of choreography with multiple movements, refinement of expressiveness to music) are usually interwoven. In our proposal, the flipped classroom structure is applied, and on-demand video lessons conduct the "learning" part of the lessons. In contrast, the "development/exercise" part is conducted by real-time online lessons (Fig. 1). By applying the aforementioned structure, the "learning" part, which requires repetition to understand the movements and make detailed corrections, can be studied repeatedly at the learners' own pace. In contrast, the "development/exercise" part, which develops and expands the expressive power of learners according to their characteristics and movements, can be conducted and explored through individual instruction and sharing with other participants. The advantage of this approach is that learners can devote time to developmental and exploratory activities such as individual instruction and sharing with other participants. We believe that the framework composed of repeated "learning" - "development/exercise" lessons enables us to provide effective lessons that develop the expressive ability of participants.

2 Related Works

Many support systems for learning dance skills have been proposed [18]. They vary from tactile [3,15] and auditory [9,14,23] systems to video presentations [1, 8, 12], use of mobile robots [11, 16, 22], gamification [4, 20], etc. In this study, we developed a dance lesson support system focusing on virtual reality(VR) technology to apply it to the flipped classroom of an online dance lesson.

Several VR-based support systems have been proposed [6, 17, 25]. Tsampounaris et al. [21] developed a system that allows users to change into different avatars, visualize traces of the movements of various body parts, and interact with virtual objects. Senecal et al. [19] developed a system for presenting virtual partners in salsa dance, where practicing with a partner is important. This study found that the motions of inexperienced participants converged with those of skilled participants upon practicing with the system. Kasahara et al. [10] found that showing a slightly futuristic video from the motion information of users made their bodies feel lighter. Various VR systems have been proposed; however, to the best of our knowledge, no systems apply flipped classrooms to an online dance lesson.

3 Preliminary investigation

3.1 Lesson design

This study has planned and implemented an online dance lesson employing the above framework and a dance instructor with immense teaching experience. The lesson is summarized below. The dance lessons were held on July 4, 15, and 22, 2020, with detailed improvements. The first lesson was an on-demand video lesson of approximately 15 minutes (the participants could watch the video repeatedly, and the actual duration depended on the participants). A video lesson was filmed and distributed to the participants, briefly explaining and demonstrating basic rhythms, dance steps, and simple choreographies combining them. The instructor filmed each movement/step and provided a detailed verbal explanation of the demonstration. The participants listened to the instructor's explanation and watched the demonstrated movements while imitating and learning the dance steps one by one. We sent the video via YouTube a few days before the real-time lesson. Subsequently, the real-time online lesson was conducted, which spanned approximately 45 minutes per lesson. In this lesson, all participants repeated the choreography that they had performed at the end of the on-demand lesson. The instructor commented on the quality, expressiveness, and areas for improvement. The participants also had time to ask questions about what they did not understand, share their impressions of the choreography in groups, and share and discuss their impressions of the dance themselves. We designed the lessons to encourage information sharing and interaction between instructors and participants. The real-time lessons were conducted using the online conference software "Zoom" (Fig. 2).

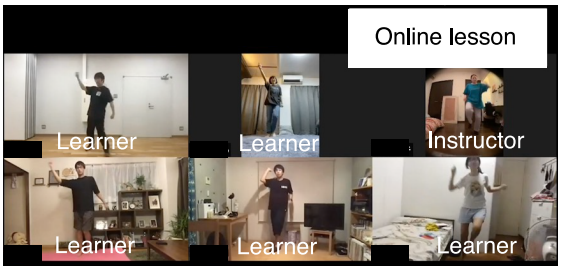

Fig. 2. A real-time lesson using Zoom. The participants attended from their own homes and nearby studios.

3.2 Participants' impressions

In the post-lesson discussions, the participants expressed their appreciation of the framework's value. Some participants felt that it was valuable to work repeatedly on the parts of the lesson that did not go well in the on-demand lesson. Furthermore, they felt they could watch other participants dance in the real-time lesson and share their impressions and awareness when dancing.

Considering the instructor's findings and the participants' feedback after the preliminary investigation, we can discuss the establishment of teaching methods tailored to individual situations in on-demand video lessons. The level of mastery of the basic steps varied greatly between participants, both in terms of type and points for improvement. Currently, there is no way to overcome this disparity other than individual guidance in real-time lessons, and this shortened the time allocated to development. The content needs to be improved to enable robust learning of the basics. This can be done by preparing videos that include detailed correction methods for the steps that the participants have difficulties with.

4 Proposed method

For preliminary investigation, we propose an online dance lesson style. The lesson style mainly consists of on-demand and real-time lessons (Fig. 3). This lesson style was structured considering a flipped classroom [13].

A flipped classroom is a teaching style that replaces the teaching traditionally conducted in the classroom (learning) with independent learning (development/exercise) modules assigned as homework. Usually, the learning occurs in the class, followed by self-learning through exercises. However, in a flipped classroom, the learning takes place through self-learning and the exercises are undertaken in the class. The advantages of this system are that learners can repeat the learning at their own pace and have more opportunities for output; further, the possibility of collaborative learning is increased, and instructors can easily monitor learners' progress. Owing to these advantages, we expected that flipped classrooms could be applied to online dance lessons for effective teaching.

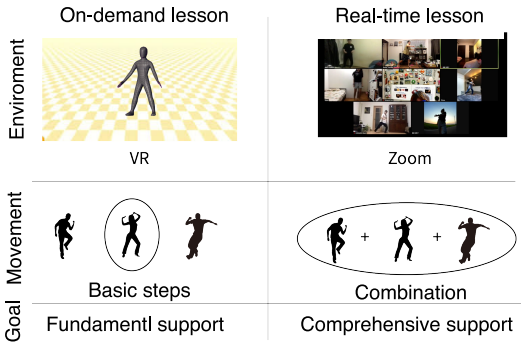

Fig. 3. Our proposed lesson style.

The application of the flipped classroom to online dance lessons is illustrated in Fig. 1. In conventional online lessons, real-time lessons using a web conferencing system such as Zoom are common. In the proposed method, the lessons are divided into two categories: on-demand and real-time. In the on-demand lesson, learners learn the basic dance steps on their own, and in the real-time lesson, they perform dance steps that combine the basic steps learned in the on-demand step. This lesson style allows detailed feedback to be returned to each learner individually, even when teaching many learners.

4.1 On-demand lesson: basic movement learning support tool

System design The preliminary investigation found that mastery of the basic steps, both in terms of type and improvement, varies between participants. To address this, we need a system that can support participant-specific modifications in on-demand lessons. Specifically, a function that automatically scores which parts of the learner's body are similar to the reference movements and to what extent, and a function that provides feedback on the scoring results, would together solve this problem.

To achieve automatic scoring, we need to acquire the motion information of the learner in real time. Moreover, these functions are also necessary for the proposed system, based on related studies, such as the ability to practice with a mirror [5], the desirability of the largest possible display when imitating movements [7], and the ability to check movements from different angles in three dimensions [24].

System Configuration Based on section 4.1 describing the system design, we developed a support system for on-demand lessons. Fig. 4 shows a system configuration. The system consists of a PC (G-Tune NM-S712SIR6SPZI), VIVE Pro Eye, and three VIVE Trackers. In addition to these devices, our system enables real-time motion tracking by utilizing the Final IK (Inverse Kinematics) library.

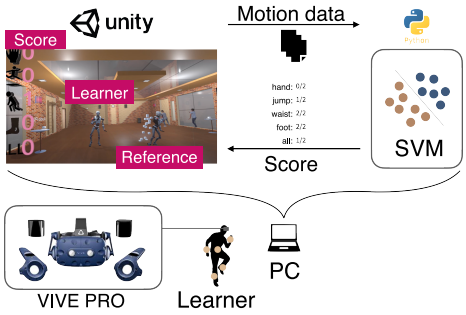

Fig. 4. System configuration.

We configured the VR lesson space in Unity and implemented the automatic scoring functionality described later in Python. Specifically, the system sends motion data from the VR lesson space to Python and automatically scores dance motions by applying them to a learning model.

Automatic Scoring In the on-demand lessons, the learners learn dance movements using the proposed system that checks and supports the acquisition of basic steps, which is a fundamental part of improving one's dancing. Specifically, we envisage the use of automatic scoring of dance steps. In basic dance steps, each body part, for example, the hips and hands, needs to be moved accurately. Therefore, by presenting a score for each body part that is important for achieving the basic dance steps, learners can check how accurately they are moving their bodies, which supports self-learning.

To build the automatic scoring function, we first collected motions of basic dance steps from dancers. We adopted the motion "New Jack Swing", a basic movement in hip-hop dance. We collected 900 movements spanning approximately two seconds each. We created a tool to visualize, edit, and score the collected motions using openFrameworks to create the training dataset. A professional dance instructor subjectively scored the collected motions in three levels. We used these data as training datasets with the correct answers labeled. The learning model used the support vector machine (SVM) machine learning method. The differences between frames of the joint positions of the 3D motion were calculated for 120 frames, and we used the mean and standard deviation of the differences as a 40-dimensional feature vector. These vectors were divided into parts for each region, each of which is trained using SVM. This process could make models in which hand, waist, foot, and overall scores can be calculated on three levels. The classification accuracy of the scores was approximately 89% for the entire body, 84% for the feet, 89% for the hands, and 94% for the waist.

User flow This section describes the procedure for using the system from the user's perspective. The system utilization procedure is shown in Fig. 5. First,

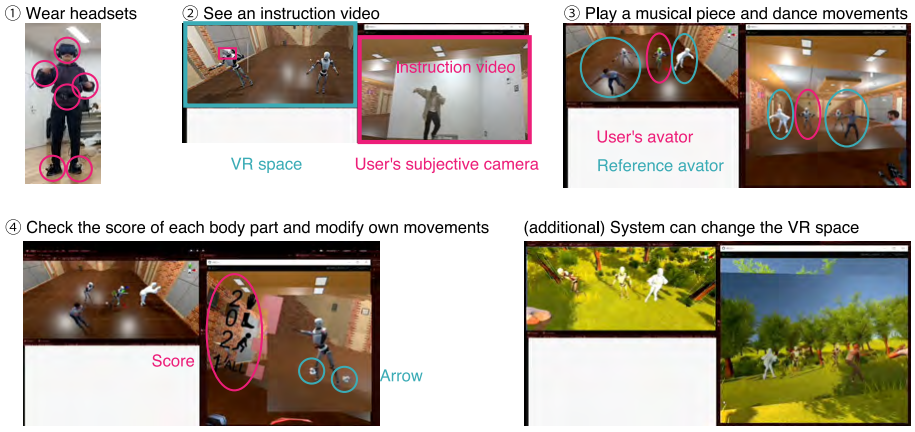

Fig. 5. User flow.

the user wears a headset and puts on trackers. Thereafter, the user enters the VR space. The user can move freely in the space by pointing to the position they want to move to while pressing a button on the controller. By pressing another button on the controller, the user can watch an instructional video, such as the one employed in the preliminary investigation. By practicing while watching this video, the user can first receive the same level of practice as the on-demand lessons in the preliminary investigation. Furthermore, the user can move on to practice using the automatic scoring function. Pressing the trigger on the controller starts the playback of the musical piece, and the reference avatar starts dancing. The user dances to the avatar's dance and watches the scoring change in real time. The user can refer to this score to understand which body parts are not being imitated accurately. In addition to the scoring display, low-scoring areas are highlighted with arrows so that the user can visually see which parts to focus on. Other advantages of VR include, for example, the possibility to place a large mirror in the open air and concentrate on practice.

4.2 Real-time lesson

The real-time lessons corresponding to the "development/exercise" in the flipped classroom focus mainly on the communication between the instructor and the learners. Specifically, the lessons will be conducted using an online conferencing system, such as Zoom, with the following flow: First, the learner demonstrates the basic steps learned in the on-demand lesson. Thereafter, the instructor instructs the learners one by one based on those basic steps. At this point, the instructor also introduces a longer choreography combining the basic steps. Comments are then shared among the participants. Finally, the instructor provides instructions on the following task, and learners return to the on-demand lesson. We believe that learners will learn more advanced steps by repeating this lesson style.

Currently, we have conducted our proposed lesson with one beginner using the proposed system. The instructor commented that the students had already learned the basic steps, and could smoothly move on to the advanced steps. They also commented the advantage of using the proposed system before the real-time lesson was that the instructor could communicate with the learner with their concerns resolved. The learner commented that they enjoyed learning as if they were in a room by themselves in the on-demand lesson. They could also receive detailed explanations of any difficulties they encountered in the real-time lesson. This feedback indicated that the proposed lesson style could be effective for online dance lessons. In the future, we would like to conduct further research with more participants and clarify the effectiveness of our proposed lesson style.

5 Summary and future work

In this study, we proposed an online dance lesson support system that enabled instructors to remotely but effectively teach multiple learners. We first focused on the framework of online dance lessons and subsequently proposed a lesson style that applied to flipped classrooms.

Structuring "development/exercise" content in real-time lessons remains challenging. Currently, the content is being closely examined based on the rich teaching experience of the lecturers. Further refinement of the content into more effective content based on clear theory remains to be achieved. In the future, we aim to construct more effective lessons for fostering expressive ability, considering the interaction between on-demand lessons and real-time lessons.

When building the proposed system, motion-capturing devices were selected considering device availability and accuracy. The minimum number of tracking devices required for learning dance steps has not been studied so far, and we could share the knowledge (six-point tracking) to help build a dance-step-learning support system in the future. We developed the proposed system on SteamVR, which can be released as an application.

Recently, VRChat has been widely used, and many users enjoy dancing on VRChat. We can use our proposed system to develop lessons for such users. There is a new type of user in VRChat that differs from those who attend traditional studio lessons. For example, we expect that many people would like to learn dancing but are embarrassed to attend a studio lesson because of the presence of many people. Our proposed system and lesson style allow VRChat users to take dance lessons and could be established as a new business model using machine learning techniques. Our system could also be used for purposes other than dance lessons, including rehabilitation and weightlifting.

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