Dance educational system to learn new Dance moves

- Master Thesis -

Project Report

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AALBORG UNIVERSITY
STUDENT REPORT

Title:
Project Title

Theme:
Master Thesis

Project Period:
Fall Semester 2023

Project Group:
XXX

Participant(s):
Julie Ulnits Sørensen

Supervisor(s):
Cumhur Erkut

Copies: 1

Page Numbers: 58

Date of Completion:
May 25, 2023

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This project aims to create a system that can teach new dance moves to dancers. It should be able to incorporate teaching methods from dancing such as learning and movement principles. Using motion capture is one of the leading technologies when it comes to capturing dancing and movements and will create a realistic digital dancing teacher. Furthermore, to entertain users gamification should also be included to show the user's progress when using the system. The application is able to track the virtual dancer and the user through a webcam in real-time and will give feedback to the user on how good they are doing by displaying their correct and incorrect steps. There will be a training session where the virtual dancer will do the moves slowly to teach the user, and afterward, a final session where the user will dance at normal speed to music. The system is developed in Python. It was tested on dancers from Move Dancestudio in Copenhagen in May 2023. Both qualitative and quantitative methods were used for data gathering. The finding shows that the system can be used for practicing and learning new dance moves, but it is not able to replace a real dance class. The findings also show it could benefit people who are too shy to take classes but still want to learn how to dance.

Master thesis: *Dance educational system to learn new dance moves*

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Abstract

This project aims to create a system that can teach new dance moves to dancers. It should be able to incorporate teaching methods from dancing such as learning and movement principles. Using motion capture is one of the leading technologies when it comes to capturing dancing and movements and will create a realistic digital dancing teacher. Furthermore, to entertain user's gamification should also be included to show the user's progress when using the system. The application can track the virtual dancer and the user through a webcam in real-time and will give feedback to the user on how good they are doing by displaying their correct and incorrect steps. There will be a training session where the virtual dancer will do the moves slowly to teach the user, and afterward, a final session where the user will dance at normal speed to music. The system is developed in Python. It was tested on dancers from Move Dance studio in Copenhagen in May 2023. Both qualitative and quantitative methods were used for data gathering. The finding shows that the system can be used for practicing and learning new dance moves, but it is not able to replace a real dance class. The findings also show it could benefit people who are too shy to take classes but still want to learn how to dance.

Keywords

Dancing, motion capture, body tracking, learning principles, and movement principles.

1. Introduction

According to recent scientific literature and documentation, motion capture technologies have been used in the field of practicing dance. In the field of dance education and teaching, technology has led to the design and development of tools to support teaching dancing. These applications present several similarities or overlaps with dance learning systems, and they investigate the analysis of movements like conceptual modeling, multimodal visualization, and transformation. Applications such as Dance Dance Revolution and Just Dance are commercial games that focus more on entertainment rather than education. Dance games do not seem to offer much in improving dance performance and learning, as usually the feedback is just judging the overall score, which does not however indicate what went wrong or suggest any improvements (Raheb, 2020).

This study focuses on creating a system that can teach dance moves while giving feedback in real time and after the performance. The purpose of the system is to take the gamification elements that work for the application of the already existing elements and add the educational parts they are missing (Raheb, 2020).

2. Related work

2.1 Motion Capture Technology

Motion capture will be the main technology for this project; therefore, it is necessary to investigate the technology behind it. Motion capture is the technology that measures the position and orientation of an object in physical space. It records the information in a computer programming language. The objects in motion capture technology can be anything from an actor to a camera or light. Motion capture is also known as; "performance animation", "virtual theater" and "digital puppet" because of its advantages in capturing performance data in animation production. Motion capture is involved in many different fields, including performing arts, fine arts, special effects in filmmaking, and computer animation. Recent academic research on motion capture focuses mostly on the digital entertainment industry – games and animation. Dance creation is only limited to the data collection and preservation of performance in motion capture technology, not dance creation itself. In the entertainment industry, there has been a collaboration between well-known dance choreographers and motion capture technology teams. In this collaboration, the technical means represent the unique audience experience of the dance performance and provide a fresh perspective of 3D (Luan, 2021).

In the digital era, more professionals use video to archive dance performances, but Motion capture surpasses the limited visual details of videotaping. Motion capture can collect data of the depth in any three-dimensional space, and capture details of movement that are difficult to be seen by human eyes. With the combination of science and arts, the virtual field has become a new direction of dance creation (Luan, 2021).

2.1.1 Rokoko & SmartSuit

The Rokoko SmartSuite II will be used in this project and it is therefore important to look into the Rokoko and their technology.

Rokoko was founded in 2014 with headquarters in Copenhagen, Denmark. They created the SmartSuit Pro which is an inertial motion capture suit. Alongside the suit, they created smart gloves for finger tracking. Alongside the suits, they have Rokoko Studio which is a motion editing tool for motion capture (Rokoko, Our story, 2023). Rokoko is

in integrations with some of the leading engines in 3D animation and creation; Blender, (Rokoko, Real-time 3D character animation & retargeting in Blender, 2023) Unreal (Rokoko, Real-time 3D character animation in Unreal, 2023), Unity (Rokoko, Real-time 3D character animation in Unity, 2023), and Maya (Rokoko, Real-time 3D character animation in Maya, 2023) etc.

The SmartSuit Pro II is the newest addition to the Rokoko smart suit collection. It is designed for indie creators and captures body motion and streams the data over Wi-Fi in real time to your digital characters. (Rokoko, rokoko.com, 2023).

Figure 1 SmartSuit Pro II (Google Images)

2.2 Dance learning practices and learning principles.

To create a system that can teach dancing to the users it is essential to understand how dancing is taught and which learning principles to follow to get the correct results.

Learning dance is a complex process and depends on various techniques. It can be linked to multimodal processes, to deliver learning objectives, the learning style of the student, and the preferences of the teacher, which will achieve the effectiveness of teaching. Whole-body interaction can benefit from the outcomes of applying it in the field of dance since dancers are experts in embodied communication and dance is by its nature multimodal (Raheb, 2020). Learning principles summarize different teaching styles applied in different practices (Camurri, 2016) (Raheb, 2020):

1. *Mimesis:* imitation/copying – the teacher teaches the student specific movements, or a sequence of movements and the student follows the movement.
2. *Generative:* The teacher gives the student a sequence as a starting point to achieve technical and creative goals.
3. *Reflective:* The student is given a movement to work with, improvising without trying to achieve a specific

phrase/sequence and the teacher provides feedback.

4. *Traditional:* The teacher makes all the decisions, and the learner follows, while the teacher commands what the student must correct or change to achieve a good performance of the movement.

Different categories of dynamics emerge out of flow in dance. These are impulse, impact, swing, rebound, and continuous. Different dance genres emphasize dynamic properties. Affinities or broken affinities between spatial and dynamic properties identify specific characteristics of a dance genre. Learning methodologies will vary between dance genres, but common to all will be developing skills in performing variations of the following actions: step, run, jump, twist, stretch, bend, swing, turn, extension, balance, gesture, and stillness (Raheb, 2020).

2.2.1 Movement Principles

Ten essential movement principles can summarize the embodied skills which are to be improved in each dance learning process, independent of the dance genre and style. The movement's Principles are as follows (Camurri, 2016):

1. *Symmetry:* The use of the two sides of the body (left and right), both in position and while moving. The ability to do the same thing simultaneously or sequentially using both sides.
2. *Directionality:* The awareness of body orientation in space. The position of the hips and torso, but interesting postures might derive from the various directions of each body part about space e.g., the audience, the camera, and the studio.
3. *Balance:* The ability to stand and move in balance, but also out of balance, depending on whether the line of gravity falls within the line of supporting limbs or not. It is the awareness of the different vector forces on the body.
4. *Alignment (Posture Stability):* The awareness of the geometry of the body and planes, and how the relations of different body parts and joints create lines in the body shape.
5. *Weight-bearing vs gesturing:* The difference between a movement that is concerned with bearing weight and a movement that is not bearing weight but has intention/expression.
6. *Gross vs. Fine Motorics/Isolation/Articulation:* The ability to distinguish small movements done by specific body parts.
7. *Coordination:* The ability to synchronize or not different parts of the

body that can move in the same or separate tempos.

8. *Motion Through space:* progressing through space or towards directions or paths etc.
9. *Rhythm and phrasing:* The ability to move in particular (predefined or improvised) rhythms.
10. *Stillness:* While movement seems to be the essence of dance, dancers need to improve their abilities to remain still.

2.3 Gamification

This project will also contain elements of games and gameful design. It is there for necessary to understand the purpose of gamification.

Gamification relates to games, not play, a broader, looser category. The distinction between games and play is tied back to Caillois's concept of paidia and ludus. Paidia denotes a more freeform, expressive, combination of behaviors and meanings, whereas ludus captures playing structured by rules and competitive strife towards a goal (Deterding, 2011).

The term gamification means that it must be analytically distinguished from playfulness or playful design. It can often give rise to playful behaviors and mindsets as well, just like a video game player can switch between playful and gameful behaviors and mindsets while playing. "Gamification" will usually coincide with a gameful design. The best strategy will therefore be to design a gameful experience and use game design elements. Gameful design and "gamification" frame the same extension through different intentional properties – The design strategy of using game design elements (Gamification) or the design goal of designing gainfulness (gameful design) (Deterding, 2011).

At figure 2 Gamification can be put against other related concepts via the two dimensions of playing/gaming and parts/whole. Both games and serious games can be differentiated from gamification through the parts/whole dimension. Playful design and toys can be differentiated through the playing/gaming dimension (Deterding, 2011).

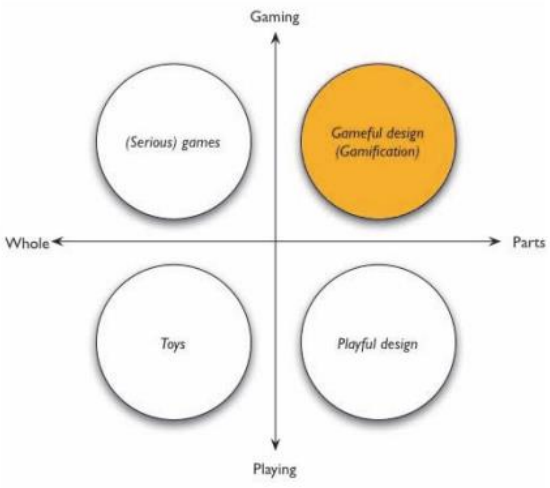

Figure 2 Diagram of the two dimensions playing/gaming & Whole/parts (Deterding, 2011)

2.3.1 Elements of Games

Reeves and Read (Reeves, 2009) have identified "Ten ingredients of Great Games": self-representation with avatars; three-dimensional environments; narrative context; feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules that are explicit and enforced; teams; parallel communication systems that can be easily configured; time pressure. These elements can be found outside of games and would not be identified as gameful. There is also variation between the different game genres and digital vs non-digital. Also, game elements can be perceived differently based on which role you have, the designer or the user (Deterding, 2011).

A game is a composite category of multiple necessary conditions, and a solution to identify game elements is to treat them as a set of building blocks or features shared by games. Therefore, gamification describes elements characteristic of two games – elements found in most games, associated with games, and played a significant role in gameplay (Deterding, 2011).

2.3.2 Game Design

Game design elements are identified on varying levels of abstraction. Five levels can be distinguished ordered from concrete to abstract: Interface design patterns; game design patterns or mechanics; design principles; conceptual models of game design units; game design methods and design processes (Deterding, 2011).

From a designer's perspective what distinguishes "Gamification from regular games and serious games is that they are built with the intention of a system that includes elements from games (Deterding, 2011).

Table 1. Levels of Game Design Elements

Level	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA; challenge, fantasy, curiosity; game design atoms; CEGE
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design, value conscious game design

Figure 3 Levels of Game design elements (Deterding, 2011)

2.4 Similar games and applications

When creating something in this field, it is important to investigate already existing dancing games and simulations.

2.4.2 Just Dance

In 2009, the first Just Dance game was made by Ubisoft using the Nintendo Wii's motion-sensing technology to offer a gaming experience. Just Dance became a benchmark for dancing games and is the number 1 music game franchise of all time (Ubisoft, 2009-

2023). The players mirror a dance performed by dancers on the screen, following moves that appear as pictorials on the screen and are awarded for their accuracy. Depending on the game and system it is played on, the game can be played with motion controllers or camera devices (Wii remote and Kinect) (Wikipedia, Just Dance(video game seris), 2022).

Figure 4 Just Dance Gameplay (Google Images)

There are no practice rounds or training sessions in Just Dance. The users are just thrown into the choreography without any practice (Raheb, 2020). The dancers in the game are not motion tracked, it is a recorded video of the dancers in full costume and make-up using a greenscreen as background (Show, 2020).

2.4.3 Dance Dance revolution

Dance Dance Revolution is a music video game series produced by Konami in Japan in 1998. It is the pioneering series of the rhythm and dance genre in video games. The player stands on a dance platform/stage and hit colored arrows laid on in a cross with their feet to musical and visual cues. The players will be judged by how well they time their dance to the patterns presented to them (Wikipedia, Dance Dance Revolution, 2023).

Dance Dance Revolution has met acclaim for its originality and stamina and for popularizing video games as a medium for fitness and exercise (Wikipedia, Dance Dance Revolution, 2023).

Figure 5 Gameplay of Dance Dance Revolution (Google Images)

Though the game does not teach actual dancing as much as remembering patterns. It only demands the user to move their feet but not the rest of the body (fundistraction, 2012).

2.5 Research question

Through the investigated areas, Motion capture and technology were identified as a great options to track dancing since video recording was limited to visual data. Furthermore, it was also found that the SmartSuit Pro II was a good technology to use

for motion capture. The existing dance games focus more on the gamification aspects and do not put as much focus on the learning and movement principles in dancing. Due to time constraints, this project is focused on teaching short steps to the users and not full routines. This led to the following research question:

How can you teach new dance moves to dancers that are not familiar or experts with a specific dance style by using motion-captured data and body tracking?

2.6 Requirements

The following requirements for the finished product are based on the research question, and what has been done previously with dancing games and simulations. The requirements below are also based on dancing learning and movement principles, alongside game elements and game design from gamification:

- The system should give feedback in real-time while the user is dancing.
- It should be made with Python using the Mediapipes Pose Landmark detection.
- The dancer should be tracked by using the SmartSuit Pro II from Rokoko.
- Incorporate some of the movement and learning principles of dancing from sections 2.2 & 2.2.1.
- Include gameful design and game elements from Gamification from section 2.3.
- The system should have a training session so the user can practice the step.
- The system should compare a recorded final video of the users dancing with the motion-tracked dancer.

3. Methods

Through this section the implementation of the system, and how it tracks the user's body movements, will be described. Furthermore, the different tests will be described, and the results will be shown. For this project, 2 tests have been made, one technical test and one user test. The technical test consisted of testing if the system's way of tracking the body made sense, and if the speed of the video was comfortable. The user test was done on dancers who were unfamiliar with the dance style and/or not professional dancers, to see if they could learn the dance steps from the system.

3.1 Design iteration approach

To make the system/game it was decided to use the vertical design iteration approach. This is when the focus is on making one functional high-fidelity prototype that could be tested on participants (Sharp H., 2015). This was done because the participant was only available for

a short amount of time due to busy schedules. Therefore, there was not enough time to do the horizontal design iteration approach (Sharp H., 2015). A small technical test was done to check for lacking in the system, and speed of the videos, and the feedback was visible and understandable.

The design will follow the learning principle of mimesis from section 2.2 since the user will be observing the dance and taught the moves by the virtual dancer and will afterward then follow the movement. The movement principles from section 2.2.1 show; symmetry, directionality, Balance, Alignment, Rhythm, and phrasing. All these movement principles are part of the dance style the professional dancer practice, therefore it is also part of the system.

The design will also fall under the gamification design from section 2.3. There will be different levels based on the easy, medium, and hard difficulties of the steps. There will also be a score displayed on the screen so the user can see how good they did.

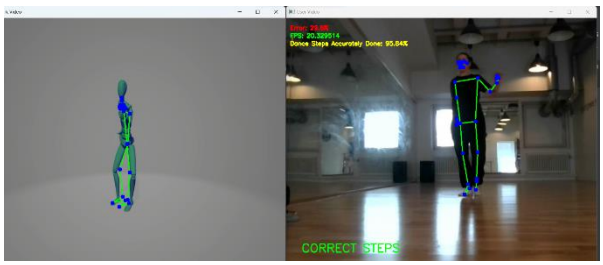

Figure 6 Display of system.

The design is mostly inspired by Just Dance from section 2.4.2. The user will follow the dancer on the screen and receive a score for how synchronized they were. The difference between this system and Just Dance is that the user gets time to practice the dance before dancing to music trying to make a replica of a dance class instead of a dance performance.

3.2 Implementation

This project was created in Python 3.8 and the programming was done in Python using Pycharm 2021.3.1 (PyCharm, u.d.). In Python, the packages Opencv (OpenCV Open Source Computer Vision, 2023) and Mediapipe (MediaPipe, u.d.) were used to track the users and the virtual dancer simultaneously on video.

OpenCV (Open source Computer Vision Library) is an open-source library that includes hundreds of computer vision algorithms. OpenCV has a modular structure, which means that the package includes shared or static libraries. The module used from OpenCV in this project is Video Analysis(video) which is a video analysis module that includes motion estimation, background subtraction, and object tracking algorithm (OpenCV Open Source Computer Vision, 2023).

MediaPipe is a cross-platform pipeline framework to build custom machine-learning solutions for live and streaming media. The

framework was op-sourced by Google and is currently in the alpha stage (MediaPipe, u.d.).

The MediaPipe pose landmark detects landmarks of human bodies in an image or a video. It can be used to identify key body locations, analyze posture, and categorize movements. It uses machine learning models that can work with single images or a video. It outputs body pose landmarks in image coordinates and 3-dimensional world coordinates (Google, u.d.).

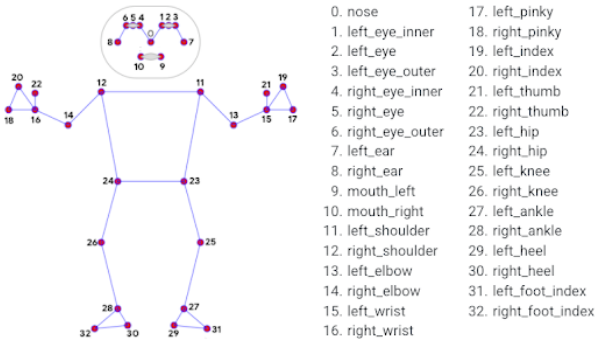

Figure 7 The Pose landmark skeleton build up (MediaPipe, u.d.)

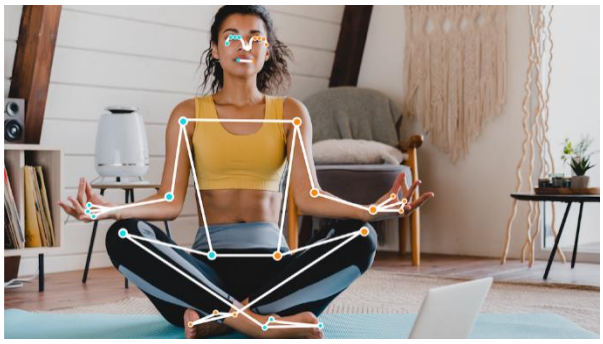

Figure 8 Pose landmark skeleton on Image (MediaPipe, u.d.)

The code for this project has taken inspiration from PrashantSaikias Body Movement comparison with Mediapipe from Github (PrashantSaikia, 2021). It is an AI that gives real-time feedback to the user on how they're performing a body movement, in this case, dancing, against a benchmark video. The benchmark video is a pre-saved file in this case a video of the motion-captured dancer. And the user video is either a pre-saved file or with a webcam (PrashantSaikia, 2021).

3.2.1 Capturing the Dancing

The motion-captured dancing was done by using the SmartSuit Pro II on a professional dancer. The dancer did several small dance moves/ routines with different difficulties. For the final system, there were two easy, one medium, and one hard dance move. The dances were done to music while recording the data. For the recorded data Rokoko Studio (Rokoko, Rokoko Studio: one software for all your mocap & animation, u.d.) was used to clean the data and afterward turned into mp4 files and added music.

3.2.2 pose_module script

The pose module script is the main script that calculates all the data and draws the virtual skeleton of the virtual dancer in the benchmark video and on the user in the webcam video. In this script, the package's math and time were imported besides OpenCV and media pipe as mentioned in section 3.2.

The math module provides access to the mathematical functions defined by the C

standard, though the functions cannot be used with complex numbers (Python, math - Mathematical functions, 2023). Time is a module that provides various time-related functions (Python, time - Time access and conversions, 2023).

The code uses self which is the instance of the class. By using self, there becomes access to the attributes and methods of the class. It binds attributes with the given arguments. The reason to use self is that Python does not use the @ syntax to refer to instance attributes. Python does methods in a way that makes the instance to which the method belongs will be passed automatically, but not received automatically. The first parameter of methods is the instance the method is called on (gyanendra371, 2022).

```
class poseDetector():

    def __init__(self, mode=False, upBody=False, smooth=True,
                 detectionCon=0.85, trackCon=0.85):

        self.mode = mode
        self.upBody = upBody
        self.smooth = smooth
        self.detectionCon = detectionCon
        self.trackCon = trackCon

        self.mpDraw = mp.solutions.drawing_utils
        self.mpPose = mp.solutions.pose
        self.pose = self.mpPose.Pose(self.mode,  self.upBody, self.smooth,
                                     self.detectionCon, self.trackCon)
```

Figure 9 Self instances

In the code, there are 4 functions: findPose, findPosition, findAngle and main.

The findPose function finds the landmarks of the virtual dancer and the user in the pose they are in. The pose_landmarks let the system detect landmarks of the human body as shown in Figure 10

```
def findPose(self, img, draw=True):
    imgRGB = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
    self.results = self.pose.process(imgRGB)
    if self.results.pose_landmarks:
        if draw:
            self.mpDraw.draw_landmarks(img, self.results.pose_landmarks,
                                       self.mpPose.POSE_CONNECTIONS)
    return img
```

Figure 10 findPose function

The findPosition function finds the position of the body. It updates the pose every time the body moves into a new position and draws the points on the body.

```
def findPosition(self, img, draw=True):
    self.lmList = []
    if self.results.pose_landmarks:
        for id, lm in enumerate(self.results.pose_landmarks.landmark):
            h, w, c = img.shape
            # print(id, lm)
            cx, cy = int(lm.x * w), int(lm.y * h)
            self.lmList.append([id, cx, cy])
            if draw:
                cv2.circle(img, (cx, cy), 5, (255, 0, 0), cv2.FILLED)
    return self.lmList
```

Figure 11 findPosition function

The findAngle function receives the landmarks, calculate the angles and draws the lines between the landmarks, and creates the skeleton seen in figure 12.

```python
def findAngle(self, img, p1, p2, p3, draw=True):

    # Get the landmarks
    x1, y1 = self.lmList[p1][1:]
    x2, y2 = self.lmList[p2][1:]
    x3, y3 = self.lmList[p3][1:]

    # Calculate the Angle
    angle = math.degrees(math.atan2(y3 - y2, x3 - x2) -
                         math.atan2(y1 - y2, x1 - x2))
    if angle < 0:
        angle += 360

    # Draw
    if draw:
        cv2.line(img, (x1, y1), (x2, y2), (255, 255, 255), 3)
        cv2.line(img, (x3, y3), (x2, y2), (255, 255, 255), 3)
        cv2.circle(img, (x1, y1), 10, (0, 0, 255), cv2.FILLED)
        cv2.circle(img, (x1, y1), 15, (0, 0, 255), 2)
        cv2.circle(img, (x2, y2), 10, (0, 0, 255), cv2.FILLED)
        cv2.circle(img, (x2, y2), 15, (0, 0, 255), 2)
        cv2.circle(img, (x3, y3), 10, (0, 0, 255), cv2.FILLED)
        cv2.circle(img, (x3, y3), 15, (0, 0, 255), 2)
        cv2.putText(img, str(int(angle)), (x2 - 50, y2 + 50),
                    cv2.FONT_HERSHEY_PLAIN, 2, (0, 0, 255), 2)
    return angle
```

Figure 12 findAngle function

The main function is the starting point of execution for the program. The execution of the program starts when the main function is defined (Learning, 2022).

```python
def main():
    cap = cv2.VideoCapture(0)
    pTime = 0
    detector = poseDetector()
    while True:
        success, img = cap.read()
        img = detector.findPose(img)
        lmList = detector.findPosition(img, draw=False)
        if len(lmList) != 0:
            print(lmList[14])
            cv2.circle(img, (lmList[14][1], lmList[14][2]), 15, (0, 0, 255), cv2.FILLED)

        cTime = time.time()
        fps = 1 / (cTime - pTime)
        pTime = cTime

        cv2.putText(img, "FPS: " + str(int(fps)), (70, 50), cv2.FONT_HERSHEY_PLAIN, 3,
                    (255, 0, 0), 3)

        cv2.imshow("Image", img)
        cv2.waitKey(1)
```

Figure 13 main function

3.2.3 move_comparison script

The move comparison script imports the pose_module script so it can use the skeleton to compare the two videos. The scipy. spatial. distance package is distance computations. It is a distance matrix computation from a collection of raw observation vectors stored in a rectangular array. In this code, the cosine is imported from that package which computes the cosine distance between 1-D arrays (SciPy, u.d.). Also imported in this is the fasdtw package which is an approximate Dynamic Time Warping (DTW) algorithm that provides optimal or near-optimal alignments with an O(N) time and memory complexity (PyPi, 2019).

In the function, it set both video size and start position. The videos are also flipped so the user would not mirror the dancing and use the wrong arms or legs when doing the movements. It will loop the videos when they end. If the last frame is reached, it will reset the capture and the frame counter.

```python
try:
    ret_val, image_1 = user_cam.read()
    # Loop the video if it ended. If the last frame is reached, reset the capture and the frame_counter
    if frame_counter == user_cam.get(cv2.CAP_PROP_FRAME_COUNT):
        frame_counter = 0  # Or whatever as long as it is the same as next line
        correct_frames = 0
        user_cam.set(cv2.CAP_PROP_POS_FRAMES, 0)

    winname = "User Video"
    cv2.namedWindow(winname)  # Create a named window
    cv2.moveWindow(winname, 720, 0)  # Move it to desired location
    image_1 = cv2.resize(image_1, (880, 640))
    image_1 = cv2.flip(image_1, 1)
    image_1 = detector_1.findPose(image_1)
    lmList_user = detector_1.findPosition(image_1)
    del lmList_user[1:11]

    ret_val_1, image_2 = benchmark_cam.read()
    # Loop the video if it ended. If the last frame is reached, reset the capture and the frame_counter
    if frame_counter == benchmark_cam.get(cv2.CAP_PROP_FRAME_COUNT):
        frame_counter = 0  # Or whatever as long as it is the same as next line
        correct_frames = 0
        benchmark_cam.set(cv2.CAP_PROP_POS_FRAMES, 0)

    image_2 = cv2.resize(image_2, (880, 640))
    image_2 = cv2.flip(image_2, 1)
    image_2 = detector_2.findPose(image_2)
    lmList_benchmark = detector_2.findPosition(image_2)
    del lmList_benchmark[1:11]
```

Figure 14 Positioning and sizing video windows

In this function, the text on the user video is also displayed. It displays the error percentages and the similarity percentages. If the similarity between the user's skeleton and the virtual dancer's skeleton is more than 90% it will take it as the user is doing the correct step and

display it. Otherwise, it will show an incorrect step.

```
        # Displaying the error percentage
        cv2.putText(image_1, 'Error: {}%'.format(str(round(100 * (float(error)), 2))), (10, 30),
                    cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 0, 255), 2)

        # If the similarity is > 90%, take it as correct step. Otherwise incorrect step.
        if error < 0.3:
            cv2.putText(image_1, "CORRECT STEPS", (40, 600),
                        cv2.FONT_HERSHEY_SIMPLEX, 1, (0, 255, 0), 2)
            correct_frames += 1
        else:
            cv2.putText(image_1, "INCORRECT STEPS", (40, 600),
                        cv2.FONT_HERSHEY_SIMPLEX, 1, (0, 0, 255), 2)
        cv2.putText(image_1, "FPS: %f" % (1.0 / (time.time() - fps_time)), (10, 50),
                    cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)
```

Figure 15 Correct or Incorrect

It will also display the dynamic accuracy of dance in percentages of frames that appear as correct. This means that for each frame the user is more than 90% similar to the virtual dancer, their percentages in their overall score will raise.

```
    # Display the dynamic accuracy of dance as the percentage of frames that appear as correct
    if frame_counter == 0:
        frame_counter = user_cam.get(cv2.CAP_PROP_FRAME_COUNT)
    cv2.putText(image_1, "Dance Steps Accurately Done: {}%".format(
        str(round(100 * correct_frames / frame_counter, 2))), (10, 70),
                cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 255), 2)
```

Figure 16 Checking for the correct step.

3.2.4 create_moves script

The create moves script loads the benchmark and user video. This code is where the user video can be changed from real-time video from the webcam to the recorded video of the test participants. This is also where the function compare_position from the move_comparision script is loaded, so it knows to use this function between the two loaded videos.

```
benchmark_video = 'dance_videos/A_Suh_E_Guh_(medium).mov'
user_video = 'ParticipantTest/Tech12.2.mp4'␣# replace with 0 for webcam
compare_positions(benchmark_video, user_video)
```

Figure 17 Loading video path.

The code gets the default resolutions of the videos. Afterward, it defines the code and filename. It will in the end release everything if the job is finished. In this code the functionality to start the recording when pressing q and stop recording when pressing q again.

```
# Get the Default resolutions
frame_width = int(cap.get(3))
frame_height = int(cap.get(4))
fps = 500

# Define the code and filename
out = cv2.VideoWriter('dance_videos/{}.mp4'.format(video_name), cv2.VideoWriter_fourcc('M', 'J', 'P', 'G'), fps, (frame_width, frame_height))

while(cap.isOpened()):
    ret, frame = cap.read()
    if ret==True:

        # write the frame
        out.write(frame)

        cv2.imshow('frame', frame)
        if cv2.waitKey(1) & 0xFF == ord('q'):
            break

    else:
        break

# Release everything if job is finished
cap.release()
cap.release()
cv2.destroyAllWindows()
```

Figure 18 Default resolution and saving with q.

3.2.5 myRecord script

The myRecord script creates the path to save the recorded video in the system. It imports the create_move function from the create_moves script (section 3.2.4) and the compare positions function from the move_comparison script (section 3.2.3). It makes sure the videos are saved in the ParticipantTest folder and the name of the videos can change based on the number of tests that have been done.

```
from create_moves import create_move
from move_comparison import compare_positions

create_move('Tech12.2')

benchmark_video = 'ParticipantTest/Test12.2.mov'
# user_video = 'dance_videos/right_dance.mp4' # replace with 0 for webcam
user_video = 0
compare_positions(benchmark_video, user_video)
```

Figure 19 Saving path

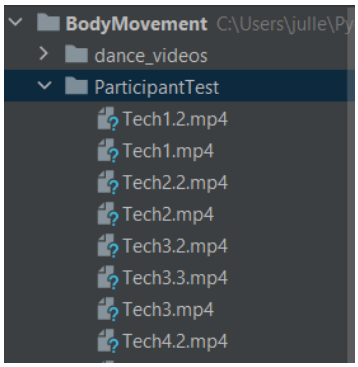

Figure 20 Saving location

3.3 Evaluation

Throughout the project, there have been conducted two tests: one technical test, and a user test of the system. Through this section, the technical test will be described, and the evaluation and results of the user test will be described. The technical test was conducted at Osramhuset in Copenhagen and the user test was conducted at move dance studio in Copenhagen.

3.3.1 Technical test

A technical test was conducted to find out if the system was ready for testing on participants. The test was conducted on the 9th of May 2023 at Osramhuset dance room in Copenhagen. The purpose of the test was to see if the feedback from the system was clear, if the video of the virtual dancer's speed was comfortable, and if any was lacking in the system that affected the dancing. The testing was only done on the part of the system that compared the real-time dancing from the webcam to the virtual dancer. This was done to ensure that any issues or flaws in the system would be fixed before the user testing.

The technical test has been conducted on 2 participants. Both participants were dancers with experience in the dance style the virtual dancer was dancing and was familiar with the dances. The test was conducted on one person at a time. The participants would first test the system and give oral feedback on what they were experiencing. Afterward, they would answer a short questionnaire documenting their feedback.

Ethics

No personal information was gathered about the participants. They signed a digital consent form to test the application anonymously. Their feedback during the testing of the system was written down by the conductor and compiled by the questionnaire answers (Mortensen, u.d.).

Recruiting Participants

To recruit participants for the testing, the Judgement sampling method was used. It is a non-probability sample method where individuals are selected based on non-random

criteria. It is also known as selective, or subjective. The researcher chooses a representative sample to suit their needs or specifically approaches individuals with certain characteristics (McCombes, 2019) (Bjørner, 2015). The participants were chosen based on their experience with the specific dance style the system shows.

Data Gathering

The data-gathering process was done using qualitative and quantitative methods. The qualitative data were gathered from the oral feedback from the participants alongside the in-depth questions they could answer. The quantitative data was from the questionnaire where the question had pre-defined short answers. The questionnaire is, therefore, a mixed-method survey (Are surveys qualitative or quantitative research?, 20221).

Results

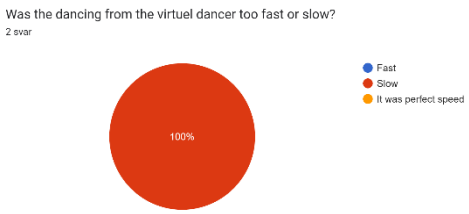

Figure 21 Speed of video technical test

The results show that the participants thought that the speed of the video was too slow and hard to dance the steps slowly since they knew the right speed of the step. Both mention to the conductor it would be a great tool to practice the step if the user did not know it.

If looking at the other responses (Appendix) the participants did not think the feedback on their dancing video was clear enough. They were only testing on a computer screen and had to stand far away for their whole body to be in the frame. They mentioned to the conductor it would be solved if it was displayed on a larger screen.

A participant responded that the program lacked a bit in the beginning, but it helped when the conductor restarted the system. The other participants said that maybe there was lacking but it was not something that bothered them. The responses can be seen in Appendix.

3.3.2 Evaluation of user testing

The evaluation of the system was conducted in a dance studio at Move Dance Studio, Copenhagen on the 14th & 16th of May 2023. The purpose of the test was to evaluate if the dancers could learn the dance moves by looking at their scores from the system. It was also to evaluate if the dancers would use a system like that to practice unknown dance moves. The purpose of the test was also to answer the research question, see section 2.5. The methods, procedures, and results from the test will be described below.

Ethics

Personal information was gathered about the participant's age and dance experience. This was done to see if they fit the target group of dancers who were either not familiar with the dance style or not professionals in the dance style (Mortensen, u.d.). The participants would stay anonymous, and all participants under the age of 18 handed in a consent form signed by a parent or legal guardian (Appendix).

Recruiting participants

To recruit participants, for testing, the judgment sampling method has been used. It was the same method used for the technical test in section 3.3.1 (Bjørner, 2015) (McCombes, 2019) This was chosen because a specific set of participants was needed to conduct the test since the opinion of dancers who were not familiar or experts with the specific dance style was the goal of the test. The approach is often used when having qualitative research (McCombes, 2019). The participants were gathered from several dance classes. Among the participants were show dancers, modern/lyrical dancers, hip-hop dancers, and beginner Dancehall dancers.

Data Gathering

The data-gathering process was done using both qualitative and quantitative methods. The qualitative data was gathered in the form of written responses in a questionnaire (see Appendix). The quantitative data was gathered in the form of option questions both in the form of yes and no questions and Likert scales, and their score from the system during the training session and the final session. The p-value was calculated to see if the results were significant alongside the Standard deviation.

Analysis methods

The qualitative data from the questionnaire will be looked through to find patterns and themes. The categorized data will be interpreted with a focus on answering the research question stated in section 2.5.

The quantitative data will be one-tailed. The one-tailed test is when the critical area of a distribution is one-sided so that it is either greater than or less than a certain value, but not both. If the sample being tested falls into the one-sided critical area, the alternative hypothesis will be accepted instead of the null hypothesis (Kenton, 2022). The p-value is a statistical measurement used to validate a hypothesis against observed data. A p-value measure the probability of obtaining the observed results, assuming that the null hypothesis is true. The lower the p-value, the greater the statistical significance of the observed difference (Beers, 2023)

A standard deviation is a measure of how dispersed the data is about the mean. A low standard deviation means data are clustered around the mean, and a high standard deviation

indicates data are more spread out. If the data points are further from the mean, there is a higher deviation within the data set; thus, the more spread out the data, the higher the standard deviation. (Hargrave, 2023).

All of this will be used to conclude that the null hypothesis will not be accepted.

Setup and procedure

The system was run on an Acer Nitro 5 AN515 laptop (proshop, u.d.). The same laptop also filmed and recorded the user video from its webcam. The system was displayed on a Samsung UE32t4002AK 32 screens (compumail, u.d.). The music played through the speakers in the dance studio. The intention of using the dance studio as a testing area was that it was a room familiar to the participants and there was enough space to dance on.

Procedure

The test took place at the Move dance studio. During the test, a conductor was present to guide the participants while they tried out the system. The conductor would also take notes of the participant's score.

The test setup would have the system displayed on a larger screen in the dance studio, and the laptop with the webcam would be placed under the table. The participants would be standing at a proper distance from the camera so their whole body got caught in the web camera. The conductor would be seated next to the screen for observation but would also be available to help if there were any questions.

The participants would be asked to hand in the signed consent form if under the age of 18 otherwise, they would agree to the terms on the laptop. They would be asked to answer the introductory questions about their dancing experience.

After that, they would be introduced to the small dance routine they have to learn by watching a video of the dance at normal speed with the music. Afterward, they would practice the step with the virtual dancer in a slowed-down version until they felt comfortable with the dance. During this, the conductor will note down their score while practicing with the system.

When they had practiced enough to their preference the system would record them doing the step at normal speed with music. The recorded video would then be compared to the virtual dancer and shown to the participant to see their score. The conductor would note down this score.

All participants had to try one easy-level dance and one medium-level dance. It was optional if they wanted to try the hard-level dance.

Results

For the test, a total of 12 participants were recruited. The participants ranged between 12-25 years old and were dancers from specific genres. 5 of the participants were dancehall dancers on beginner level which was the dance style they had to learn moves from the system. The rest of the participants were either aware or familiar with the dance style but did not dance it. The results from the participants who took dancehall classes were considered that they had more experience than the others with the dance moves. It will also be considered that only 5 of the participants tried the hard-level dance.

Quantitative results

The Null hypothesis is stated:

H0 = Dancers cannot learn new steps from a dance simulation

The Alternative Hypothesis is stated:

Ha = Dancers can learn new steps from a dance simulation

The following data should help reject the Null hypothesis. All data and figures can also be seen in the Appendix.

Scores from system

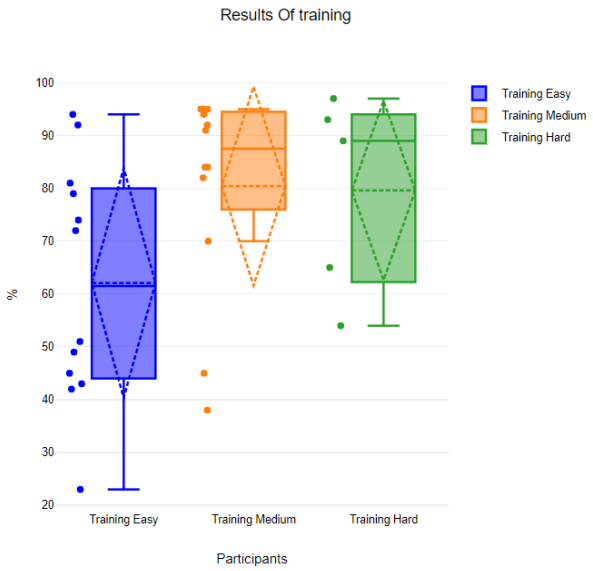

Figure 22 Results for training sessions scores

Figure 22 shows the results scores of the training session with all three levels of dancing in boxplots. The score for all participants was raised from the easy training level to the medium training level. The outliers for the easy level were 23 and 94. The outlier for the medium level was 38 and 95. This can indicate that the participants adapted to the program the more they practiced with it. The outlier for the hard level was 54 and 97.

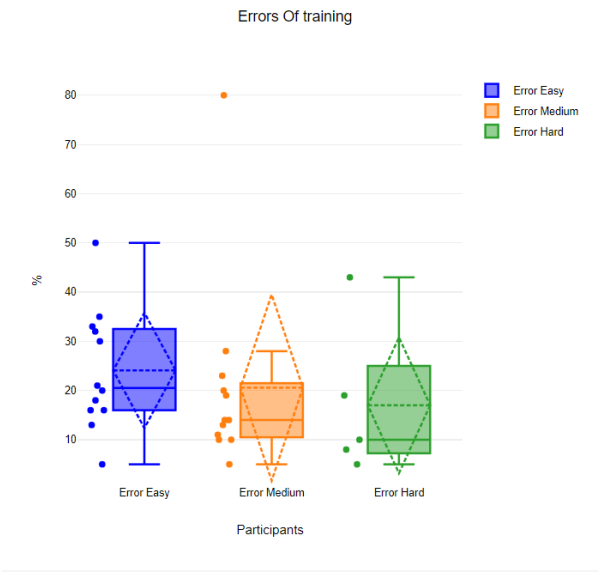

Figure 23 Error score from a training session

Figure 23 shows the error scores of the training session with all three levels of dancing in boxplots. The error score was highest in the easy-level dance moves. This could indicate it was easier to make flaws with the easy-level training session, but they also progressed when trying the medium-level dance. The outlier for the easy level is 21 and 50. The outliers for the medium level are 5 and 80. The outliers for the hard level are 5 and 43.

Overall, these results show that participants got a higher score while training with the system than making errors. The P-value shows that $p < 0.05$ for all 3 levels both for results and error which therefore made the data significant. And the standard deviation was relatively low which meant the data was clustered around the mean. All the data calculations can be seen in Appendix.

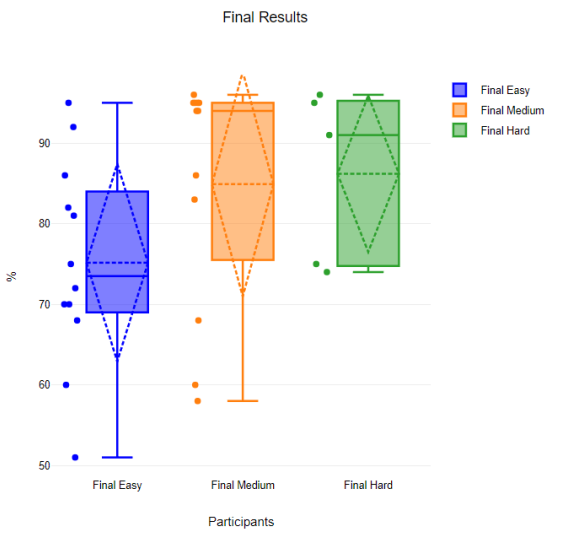

Figure 24 Final Result score

Figure 24 shows the results scores of the Final session with music for all three levels of dancing in boxplots. The score for all participants was raised from the easy level to the medium level. The hard level was for the 5 participants same level as medium. The outliers for the easy level were 51 and 95. The outlier for the medium level was 58 and 96. The outliers for the hard level were 74 and 96.

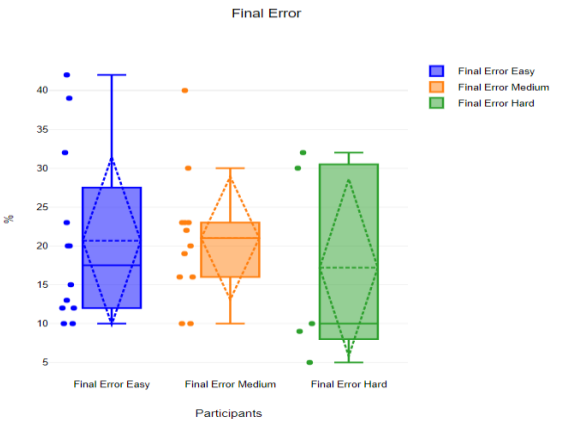

Figure 25 Final error scores

Figure 25 shows the error scores of the final session with all three levels of dancing in boxplots. The error score was highest in the easy-level dance moves. This could indicate it was easier to make flaws with the easy-level, but they also progressed when trying the medium-level dance. The outlier for the easy level is 10 and 42. The outlier for the medium level is 10 and 40. The outliers for the hard level are 5 and 32.

These results show that none of the participants got a score lower than 51 which means there was a big improvement from the training session. It also shows that none one got an error score higher than 42. The P-value shows that $p < 0.05$ for all 3 levels both for results and error which therefore made the data significant. And the standard deviation was relatively low which meant the data was clustered around the mean. All the data calculations can be seen in Appendix.

To sum up the score results from the system the participants got better scores when dancing with music than in the training session, and most participants scored best in the medium-level dance. This indicates the training session benefitted the participants when they had to dance to music.

Scores from questionnaire

The participants were asked to fill out the rest of the questionnaire with questions about their opinion of the system. Some of the questions included a Likert scale where 1 strongly disagreed and 5 strongly agree.

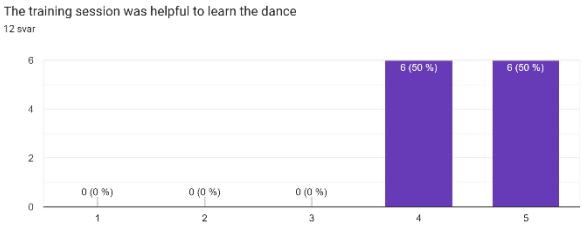

Figure 26 Scores for the training session were helpful.

Figure 26 shows the results of the first Likert scale asking the participants if the training session was helpful to learn the dance. 6 participants answered 4 and 6 participants answered 5.

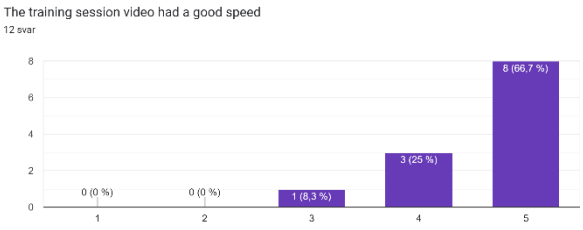

Figure 27 Scores for training session video speed

Figure 27 shows the results of the second Likert scale asking the participants if the training session video had a good Speed. 1 participant answered 3, 3 participants answered 4, and 8 participants answered 5.

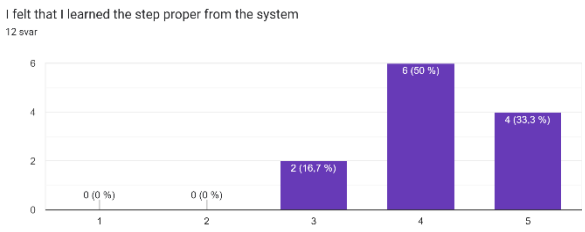

Figure 28 Scores for if the participants learned the step proper.

Figure 28 shows the results of the third Likert scale asking the participants if they felt they learned the step properly from the system. 2 participants answered 3, 6 participants answered 4, and 4 participants answered 5.

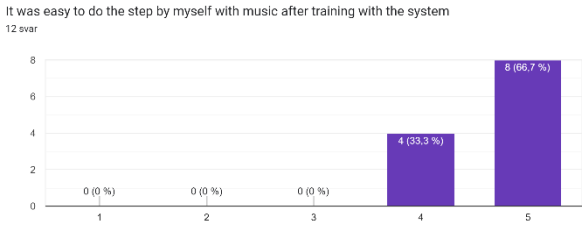

Figure 29 Score for it was easy to do the step after a training session

Figure 29 shows the results of the fourth and final Likert scale asking the participants if it was easy to do the step by themselves with music after doing the training session. 4 participants answered 4 and 8 participants answered 5.

The P-values for all the Likert scales show that $p < 0.05$. The standard deviation was relatively low which meant the data was clustered around the mean. All the data can be seen in Appendix.

Overall, these results complement the results from the system. The participants felt they learned the step proper from the system and it was easy to do the step after doing the training system.

Both results from the system and the questionnaire can conclude that the alternative hypothesis can be accepted and the Null hypothesis is incorrect.

Qualitative data

The participants were first asked about their overall experience. All participant's feedback was directed towards it was a nice useful and fun system, but it was missing a few things from the real world:

"The virtual dancer made the step overcoming and easy to understand, even though a groove is not something a virtual dancer can give you."

"It was great! The video helped me do the steps right. Especially the practice video helps a lot before doing the step as you should".

The participants were also asked how they felt about their results after being compared to the virtual dancer. Most participants were satisfied with their results, but some also felt they looked a bit stupid because they were not familiar with the dance style:

"I looked stupid - but less stupid, than if the virtual dancer had not taught me."

"I think it was very good and also very surprising"

In the questionnaire, the participants were asked questions on how they would use the system if it was fully functional.

The first question was asked if they would replace real dance classes with a system like this. 8 out of 12 participants said no and 4 out of 12 said yes. Most participants liked the system overall but said it would not be the same as taking a real physical dance class:

"I'm old school, and have been dancing since I was four. A computer can't make up for a teacher".

"I like to have a dance teacher, but for new dance steps I think it will be helpful."

A few participants saw the possibilities for a system like this to help people who were too shy to take dance classes:

"It will help a lot of people to dance with a virtual dancer instead of going to dance classes. Especially because there are a lot of people that feel shy when dancing with unknown people. This would help the shy people a lot."

The second question was asked if they would use a system like this to practice for their next dance class. 11 out of 12 said yes and 1 out of 12 said no.

Almost all participants agreed that it would be a nice system to practice with before class.

"very good way to prepare for a class or make sure you understood the steps correctly"

The last question asked if they would use the system to learn moves from a dance style, they did not take classes for. All participants answered yes.

All participants agreed that it was a nice system to open up possibilities for new dance styles:

"When you're new at something, it is comfortable to learn from a virtual dancer before going to dance lessons"

"It's cool if you suddenly have to learn a new dance style that you know a few steps but also the vibe"

These results show overall the participants enjoyed the system and it would be something they could use for practicing and learning something new. But it would not be the same as taking a normal dance class because some things are hard to digitalize. All Data from the questionnaire can be found in Appendix.

4. Discussion

This section is focused on reflecting on the different aspects of this project. First, the

testing methods and results will be discussed regarding validity and reliability as well as answering the research question. Furthermore, more specific aspects of the project will be discussed with a focus on either potential error during the test and/or future improvements.

4.1 Validity & Reliability

Validity and reliability are important to consider ensuring that the test conducted can be considered to have valid and reliable results. First validity will be discussed, which is whether there was used the appropriate test procedure. Afterward, the reliability will be discussed, which considers the consistency of the measurement strategy (Bjørner, 2015).

Validity

Triangulation was performed in the study since some of the questions in the questionnaire participants would give their personal opinions. This would give different perspectives which will give justification for the findings (Bjørner, 2015).

Due to time constraints, member checking would not be carried out, since there would be no time to get the participants back for a follow-up test (Bjørner, 2015). Another reason was that the participants would not all be gathered at the same time. They were under specific circumstances gathered on the 14th of May, where 3 of them were able to show on the 16th of May.

There was bias since it was a physical test where participants can be affected by the conductor or the environment while testing. They were also biased because several of them were the dance students of the conductor otherwise they were familiar with the conductor. This could affect the results because they wanted to give good feedback, which is why the conductor did not observe them while answering questions. The last thing is most participants knew each other because they were in the same dance classes and could affect each other opinions before testing (Bjørner, 2015).

Reliability

The data collection was consistent so the study can be deemed reliable. The conductor was present during the testing and the participants were therefore being observed during the test except when they answered questions the conductor did not leave the room but where not watching the participants when they gave their answers to no effect on the results.

4.2 Evaluation of test results

As mentioned in section 3.3.2, the participants have different experiences in dancing. 5 of the participants had experience with the specific dance style the system was teaching and had

therefore an advantage compared to the other participants. The majority of the 5 participants scored high but some of them also had an average score. Some of the dancers that had no experience with the dance style also managed to get high scores even though they lacked experience. This could be the course of the chosen teaching style for the system which was the mimesis method from section 2.2. Students learn differently where some are good at observing and adapting while others need further explanation on what to do with their bodies.

It was also shown in the quantitative result in section 3.3.2 that most participants had a harder time doing the easy dance than the medium dance. This could be because they had to get used to the system and dance style and were more comfortable during the medium dance. It could also be that the medium and easy dance should be switched around. The medium dance was chosen because it included a turn and a specific groove which could be harder during the movement principles alignment, rhythm, and balance from section 2.2.1 that the move included.

4.3 Delay in recorded video

When recording the participants and comparing it to the video of the virtual dancer there was a delay in the videos. The recorded video started later than the video of the virtual dancer and was there for a few frames behind. This could affect the results a bit because the user's video would be a bit behind and not follow the virtual dancer in synchronization.

4.4 Sensitive body tracking

The body-tracking skeleton was very sensible. It showed several times the dancers were correct in their movements even though they had not started dancing yet. This was the case because if the upper body was in the right position, but they did not move their feet they still were over 90% synchronized with the virtual dancer. This was mostly during the training session, and the score would not be considered until the user started dancing.

4.5 Future Aspects

The future of the system created in this project, showed promising signs, by having the participants show enjoyment and interest in using a similar system to practice their dancing. The system would have to be updated regarding a more stable body tracking and fixing the delay in the recorded video. The technical test also showed that when the video of the technical dancer was in the system it was too slow, which was why the decision on making a training session was made. The system should include loading the video with music and proper speed while using it. Though, the focus of this project was to make the

system teach new dance styles more gamification elements from section 2.3 should be included to make the system more enjoyable and closer to a game. The future for this project will therefore be to build a more functional game based on the way this system works.

5. Conclusion

It was found that a system that follows learning and movement principles of dancing and includes gamification could teach dancers new dance moves. To answer the research question stated in section 2.5 it is found that having a training session before letting them make it easier for the participants to learn the dance moves and made them feel more confident in what they were doing. Though some participants stated that this could not replace a real dance class and a real teacher because there are some things technology cannot implement, the system was a promising practice tool.

Looking at the test results nothing was missing from the system to answer the research question. But for further development, it could focus on adding more gamification elements and even other dance styles. It could also be researched about what the system was missing for it to feel like it was a real dance teacher and a real dance class. The purpose of this project was not to replace dance classes but to give dancers a tool to practice with especially if they were not familiar with a specific dance style, in which the results both qualitative and quantitative were the case.

Acknowledgement

I would like to thank Cumhur Erkut, Henrik Schønau Fog, and Soyinka Wole Mitchell for discussions and research contributions to this study.

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Appendix

Implementation

move_comparison.py myRecord.py create_moves.py pose_module.py

```python
import cv2, time
import pose_module as pm
from scipy.spatial.distance import cosine
from fastdtw import fastdtw


def compare_positions(benchmark_video, user_video):
    benchmark_cam = cv2.VideoCapture(benchmark_video)
    user_cam = cv2.VideoCapture(user_video)

    fps_time = 0  # Initializing fps to 0

    detector_1 = pm.poseDetector()
    detector_2 = pm.po
    frame_counter = 0
    correct_frames = 0

    while (benchmark_cam.isOpened() or user_cam.isOpened()):
        try:
            ret_val, image_1 = user_cam.read()
            # Loop the video if it ended. If the last frame is reached, reset the capture and the frame_counter
            if frame_counter == user_cam.get(cv2.CAP_PROP_FRAME_COUNT):
                frame_counter = 0  # Or whatever as long as it is the same as next line
                correct_frames = 0
                user_cam.set(cv2.CAP_PROP_POS_FRAMES, 0)

            winname = "User Video"
            cv2.namedWindow(winname)  # Create a named window
            cv2.moveWindow(winname, 720, 0)  # Move it to desired location
```

Fetching Documentation...

```python
            cv2.namedWindow(winname)  # Create a named window
            cv2.moveWindow(winname, 720, 0)  # Move it to desired location
            image_1 = cv2.resize(image_1, (800, 640))
            image_1 = cv2.flip(image_1, 1)
            image_1 = detector_1.findPose(image_1)
            lmList_user = detector_1.findPosition(image_1)
            del lmList_user[1:11]

            ret_val_1, image_2 = benchmark_cam.read()
            # Loop the video if it ended. If the last frame is reached, reset the capture and the frame_counter
            if frame_counter == benchmark_cam.get(cv2.CAP_PROP_FRAME_COUNT):
                frame_counter = 0  # Or whatever as long as it is the same as next line
                correct_frames = 0
                benchmark_cam.set(cv2.CAP_PROP_POS_FRAMES, 0)

            image_2 = cv2.resize(image_2, (800, 640))
            image_2 = cv2.flip(image_2, 1)
            image_2 = detector_2.findPose(image_2)
            lmList_benchmark = detector_2.findPosition(image_2)
            del lmList_benchmark[1:11]

            frame_counter += 1

            if ret_val_1 or ret_val:
                error, _ = fastdtw(lmList_user, lmList_benchmark, dist=cosine)

                # Displaying the error percentage
                cv2.putText(image_1, 'Error: {}%'.format(str(round(100 * (float(error)), 2))), (10, 30),
                            cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 0, 255), 2)
```

```
            # If the similarity is > 90%, take it as correct step. Otherwise incorrect step.
            if error < 0.3:
                cv2.putText(image_1, "CORRECT STEPS", (40, 600),
                            cv2.FONT_HERSHEY_SIMPLEX, 1, (0, 255, 0), 2)
                correct_frames += 1
            else:
                cv2.putText(image_1, "INCORRECT STEPS", (40, 600),
                            cv2.FONT_HERSHEY_SIMPLEX, 1, (0, 0, 255), 2)
            cv2.putText(image_1, "FPS: %f" % (1.0 / (time.time() - fps_time)), (10, 50),
                        cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)

            # Display the dynamic accuracy of dance as the percentage of frames that appear as correct
            if frame_counter == 0:
                frame_counter = user_cam.get(cv2.CAP_PROP_FRAME_COUNT)
            cv2.putText(image_1, "Dance Steps Accurately Done: {}%".format(
                str(round(100 * correct_frames / frame_counter, 2))), (10, 70),
                        cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 255), 2)

            # Display both the benchmark and the user videos
            cv2.imshow('Benchmark Video', image_2)
            cv2.imshow('User Video', image_1)

            fps_time = time.time()
            if cv2.waitKey(1) & 0xFF == ord('q'):
                break
        else:
            break
    except:
        pass
```

```
    benchmark_cam.release()
    user_cam.release()
    cv2.destroyAllWindows()
```

move_comparison.py | myRecord.py | create_moves.py | pose_module.py

```
from create_moves import create_move
from move_comparison import compare_positions

create_move('Tech12.2')

benchmark_video = 'ParticipantTest/Test12.2.mov'
# user_video = 'dance_videos/right_dance.mp4' # replace with 0 for webcam
user_video = 0
compare_positions(benchmark_video, user_video)
```

move_comparison.py myRecord.py create_moves.py pose_module.py

```python
import cv2
from move_comparison import compare_positions

benchmark_video = 'dance_videos/A_Suh_E_Guh_(medium).mov'
user_video = 'ParticipantTest/Tech4.2.mp4' # replace with 0 for webcam
compare_positions(benchmark_video, user_video)

def create_move(video_name):
    cap = cv2.VideoCapture(0)

    # Get the Default resolutions
    frame_width = int(cap.get(3))
    frame_height = int(cap.get(4))
    fps = 500

    # Define the code and filename
    out = cv2.VideoWriter('dance_videos/{}.mp4'.format(video_name), cv2.VideoWriter_fourcc('M', 'J', 'P', 'G'), fps, (frame_width, frame_heigh

    while(cap.isOpened()):
        ret, frame = cap.read()
        if ret==True:

            # write the frame
            out.write(frame)

            cv2.imshow('frame', frame)
            if cv2.waitKey(1) & 0xFF == ord('q'):
                break
```

```python
            # write the frame
            out.write(frame)

            cv2.imshow('frame', frame)
            if cv2.waitKey(1) & 0xFF == ord('q'):
                break

        else:
            break

# Release everything if job is finished
cap.release()
cap.release()
cv2.destroyAllWindows()
```

move_comparison.py myRecord.py create_moves.py pose_module.py

```python
import cv2
import mediapipe as mp
import time
import math


class poseDetector():

    def __init__(self, mode=False, upBody=False, smooth=True,
                 detectionCon=0.85, trackCon=0.85):

        self.mode = mode
        self.upBody = upBody
        self.smooth = smooth
        self.detectionCon = detectionCon
        self.trackCon = trackCon

        self.mpDraw = mp.solutions.drawing_utils
        self.mpPose = mp.solutions.pose
        self.pose = self.mpPose.Pose(self.mode,  self.upBody, self.smooth,
                                     self.detectionCon, self.trackCon)

    def findPose(self, img, draw=True):
        imgRGB = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        self.results = self.pose.process(imgRGB)
        if self.results.pose_landmarks:
            if draw:
                self.mpDraw.draw_landmarks(img, self.results.pose_landmarks,
                                           self.mpPose.POSE_CONNECTIONS)
        return img

    def findPosition(self, img, draw=True):
        self.lmList = []
        if self.results.pose_landmarks:
            for id, lm in enumerate(self.results.pose_landmarks.landmark):
                h, w, c = img.shape
                # print(id, lm)
                cx, cy = int(lm.x * w), int(lm.y * h)
                self.lmList.append([id, cx, cy])
                if draw:
                    cv2.circle(img, (cx, cy), 5, (255, 0, 0), cv2.FILLED)
        return self.lmList

    def findAngle(self, img, p1, p2, p3, draw=True):

        # Get the landmarks
        x1, y1 = self.lmList[p1][1:]
        x2, y2 = self.lmList[p2][1:]
        x3, y3 = self.lmList[p3][1:]

        # Calculate the Angle
        angle = math.degrees(math.atan2(y3 - y2, x3 - x2) -
                             math.atan2(y1 - y2, x1 - x2))
```

```
                        math.atan2(y1 - y2, x1 - x2))
        if angle < 0:
            angle += 360

        # Draw
        if draw:
            cv2.line(img, (x1, y1), (x2, y2), (255, 255, 255), 3)
            cv2.line(img, (x3, y3), (x2, y2), (255, 255, 255), 3)
            cv2.circle(img, (x1, y1), 10, (0, 0, 255), cv2.FILLED)
            cv2.circle(img, (x1, y1), 15, (0, 0, 255), 2)
            cv2.circle(img, (x2, y2), 10, (0, 0, 255), cv2.FILLED)
            cv2.circle(img, (x2, y2), 15, (0, 0, 255), 2)
            cv2.circle(img, (x3, y3), 10, (0, 0, 255), cv2.FILLED)
            cv2.circle(img, (x3, y3), 15, (0, 0, 255), 2)
            cv2.putText(img, str(int(angle)), (x2 - 50, y2 + 50),
                        cv2.FONT_HERSHEY_PLAIN, 2, (0, 0, 255), 2)
        return angle


def main():
    cap = cv2.VideoCapture(0)
    pTime = 0
    detector = poseDetector()
    while True:
        success, img = cap.read()
        img = detector.findPose(img)
        lmList = detector.findPosition(img, draw=False)
        if len(lmList) != 0:
```

```
            print(lmList[14])
            cv2.circle(img, (lmList[14][1], lmList[14][2]), 15, (0, 0, 255), cv2.FILLED)

        cTime = time.time()
        fps = 1 / (cTime - pTime)
        pTime = cTime

        cv2.putText(img, "FPS: " + str(int(fps)), (70, 50), cv2.FONT_HERSHEY_PLAIN, 3,
                    (255, 0, 0), 3)

        cv2.imshow("Image", img)
        cv2.waitKey(1)


if __name__ == "__main__":
    main()
```

Technical Test

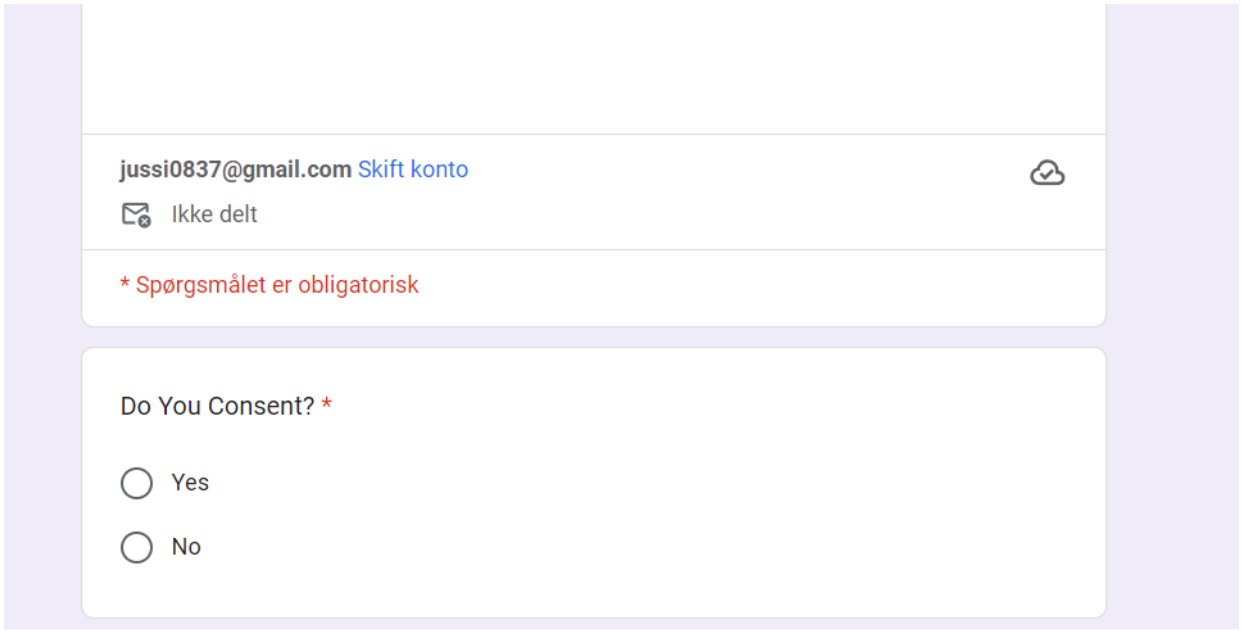
Technical Testing

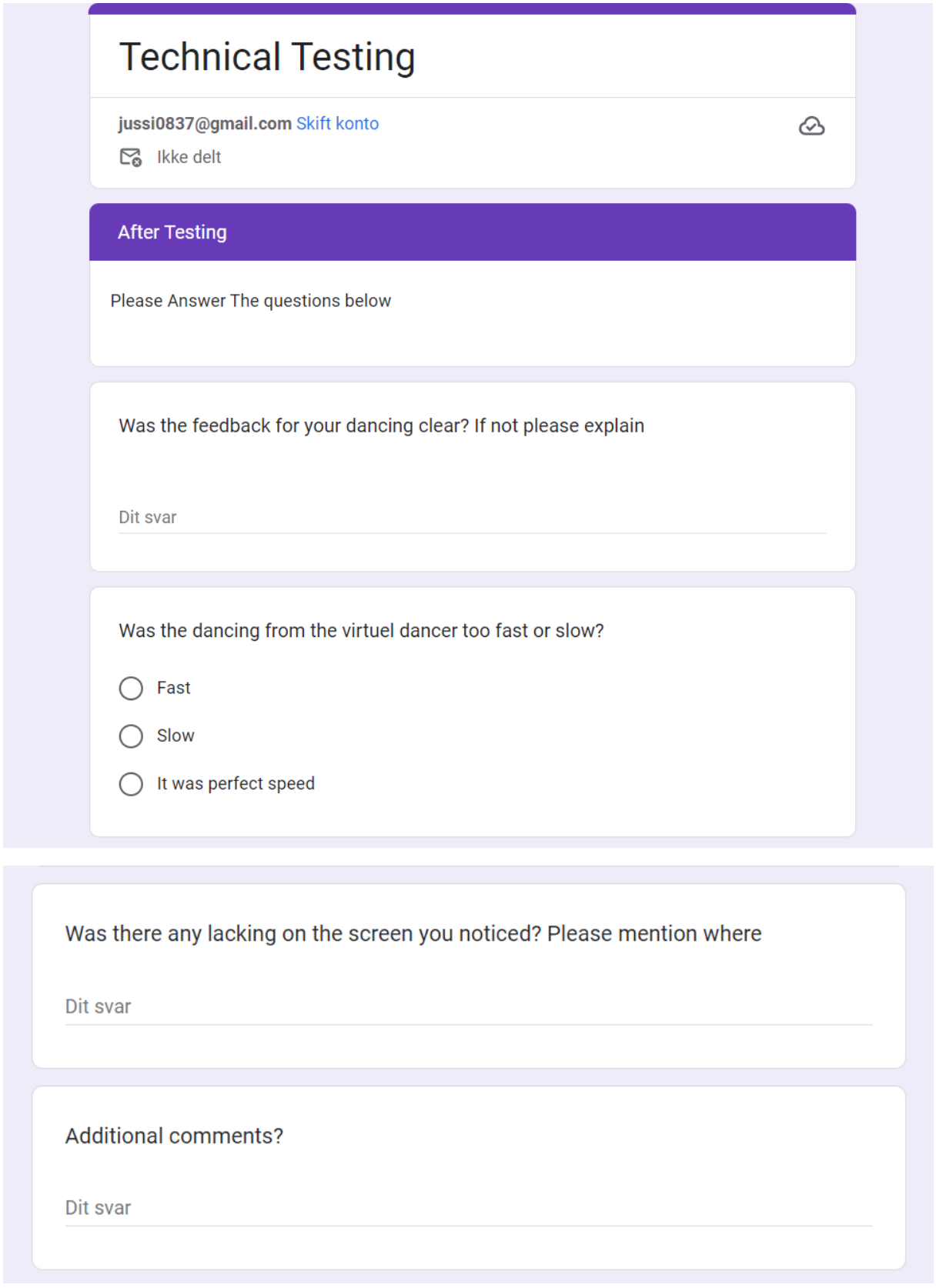
The purpose of the
testing is to let the participants try out a prototype of a dancing simulation. The participant will be introduced to 3 different dances by a virtual dancer and try to learn the dance moves. The participant will be recorded alongside the virtual dancer and given a score of how equal their dancing is to the virtual dancer.

The participants will
be asked a few questions about how they felt the system worked itself to be able to correct the system for the official testing.

All collected data will
be used for the project until the exam has taken place in June. The participation will be anonymous.

1. I confirm that I have read and understand the above outline
   of the research.
2. understand that my participation is voluntary and
   that I am free to withdraw at any time, without giving any reason.
3. I understand that my data will be used for the researchers
   Master project and will be part of evaluating the project.
4. I understand that my participation will be anonymous
5. I confirm that the researcher will be allowed to video
   record me during the testing
6. I agree to take
   part in the above study.


jussi0837@gmail.com Skift konto
Ikke delt
* Spørgsmålet er obligatorisk
Do You Consent? *
Yes
No



Technical Testing

jussi0837@gmail.com Skift konto

Ikke delt

After Testing

Please Answer The questions below

Was the feedback for your dancing clear? If not please explain

Dit svar

Was the dancing from the virtuel dancer too fast or slow?

- Fast
- Slow
- It was perfect speed

Was there any lacking on the screen you noticed? Please mention where

Dit svar

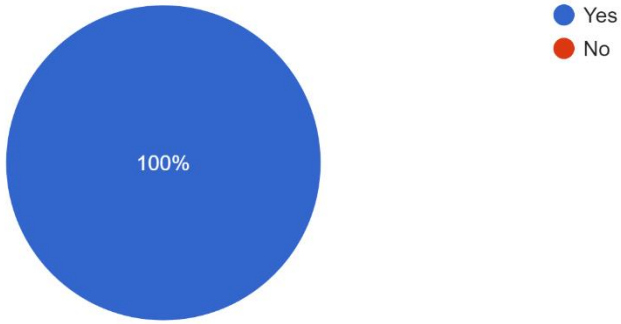
Additional comments?

Dit svar

Technical Test Result

Do You Consent?

2 svar



After Testing

Was the feedback for your dancing clear? If not please explain

1 svar

no

Was the dancing from the virtuel dancer too fast or slow?

2 svar

Was there any lacking on the screen you noticed? Please mention where

2 svar

Only to begin with. But restarting corrected the issue

måske

Additional comments?

1 svar

tak

User test

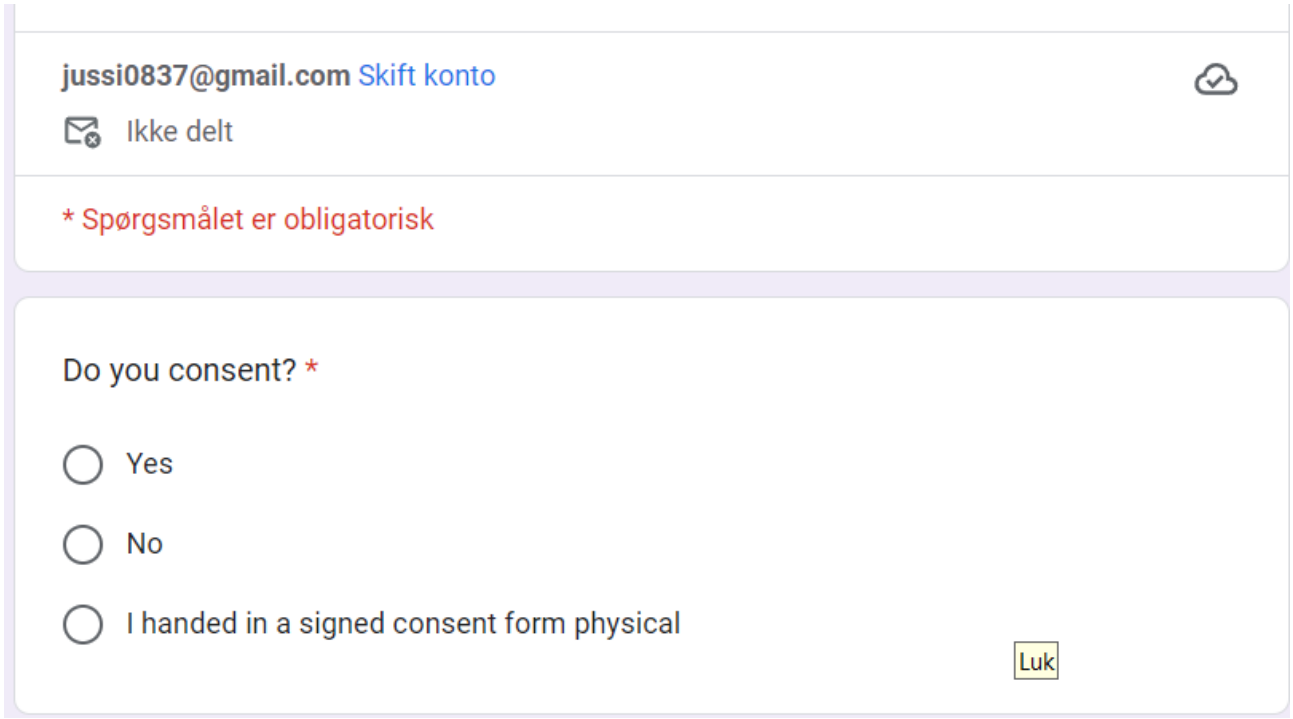
User Testing

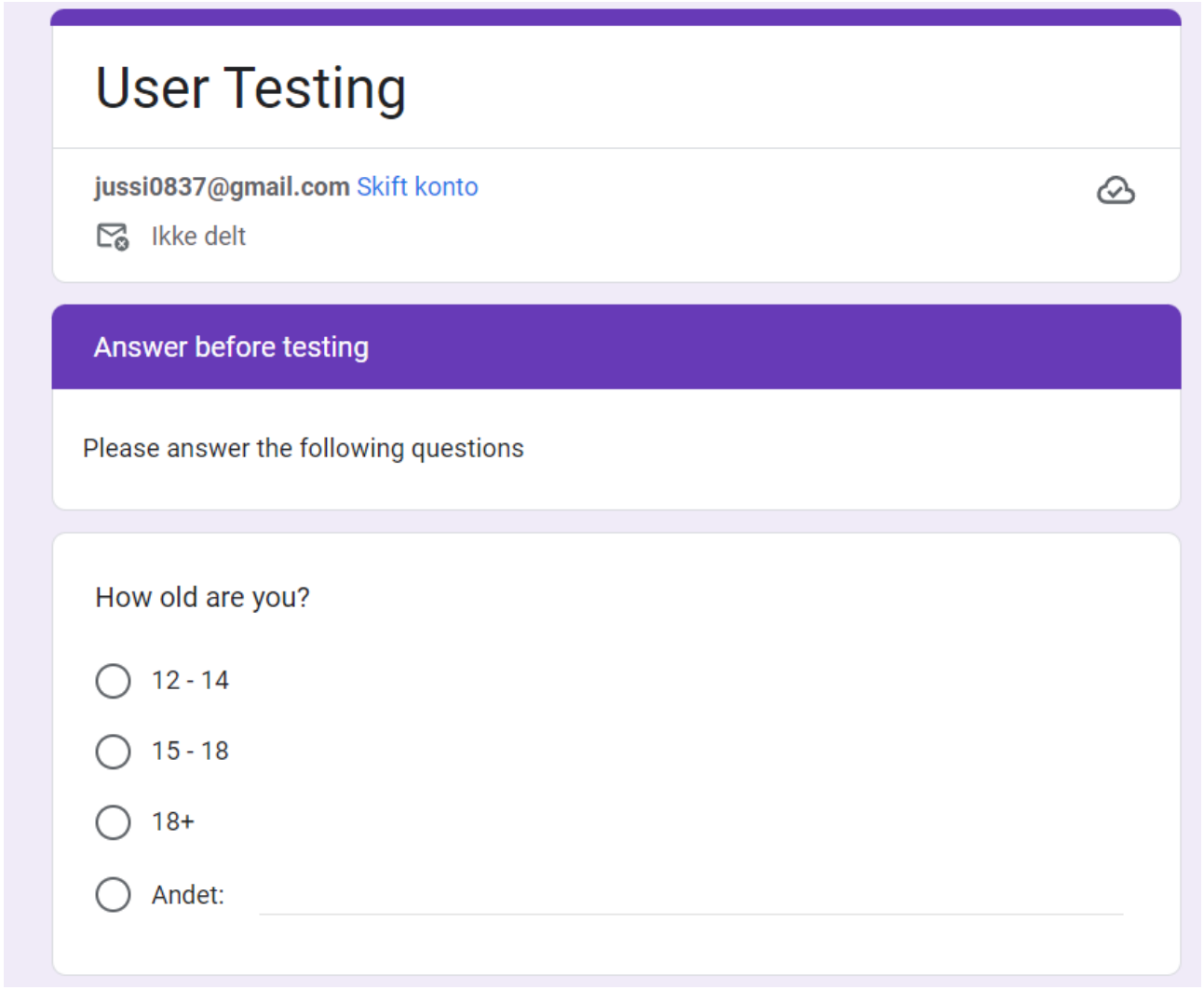
The purpose of the
testing is to let the participants try out a prototype of a dancing simulation. The participant will be introduced to 3 different dances by a virtuel dancer and try to learn the dance moves. The participant will be recorded alongside the virtuel dancer and given a score of how equal their dancing is to the virtuel dancer.

The participants will
be asked a few questions about their dancing background and which specific dance style they normally work with.

All collected data will
be used for the project until the exam has taken place in June. The participation will be anonymous

1. I confirm that I have read and understand the above outline
   of the research.
2. I understand that my participation is voluntary and
   that I am free to withdraw at any time, without giving any reason.
3. I understand that my data will be used for the researchers
   Master project and will be used as part of evaluating the project.
4. I understand that my participation will be anonymous
5. I confirm that the researcher will be allowed to video
   record me during the testing
6. I agree / do not agree (delete as applicable) to take
   part in the above study.


jussi0837@gmail.com Skift konto
Ikke delt
* Spørgsmålet er obligatorisk
Do you consent? *
Yes
No
I handed in a signed consent form physical
Luk


User Testing
jussi0837@gmail.com Skift konto
Ikke delt
Answer before testing
Please answer the following questions
How old are you?
12 - 14
15 - 18
18+
Andet:

How long have you danced for?

- ◯ 1 - 3 years
- ◯ 4 - 6 years
- ◯ 7 - 9 years
- ◯ 10+ years

Which dance style do you practice?

- ◯ Hiphop
- ◯ Showdance
- ◯ Modern/Lyrical
- ◯ Andet: _____

Are you familiar with the dancestyle Dancehall?

- ◯ No
- ◯ I know the style but I do not dance it
- ◯ I am familar with it
- ◯ I take Dancehall Classes

User Testing

jussi0837@gmail.com Skift konto

Ikke delt

Video of virtuel dancer

Please answer the following questions

Did the video of the virtual dancer give you an understanding on how to do the step?

- ◯ Yes
- ◯ No
- ◯ Andet: _____

Did the video of the virtual dancer give an understanding of the speed of the step?

- ◯ Yes
- ◯ No
- ◯ Andet: _____

How was your overall experience of the video?

Dit svar

User Testing

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Ikke delt

Training session

On a scale of 1-5 where 1 is strongly disagree and 5 is strongly agree , please answer the following statements

The training session was helpful to learn the dance

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The training session video had a good speed

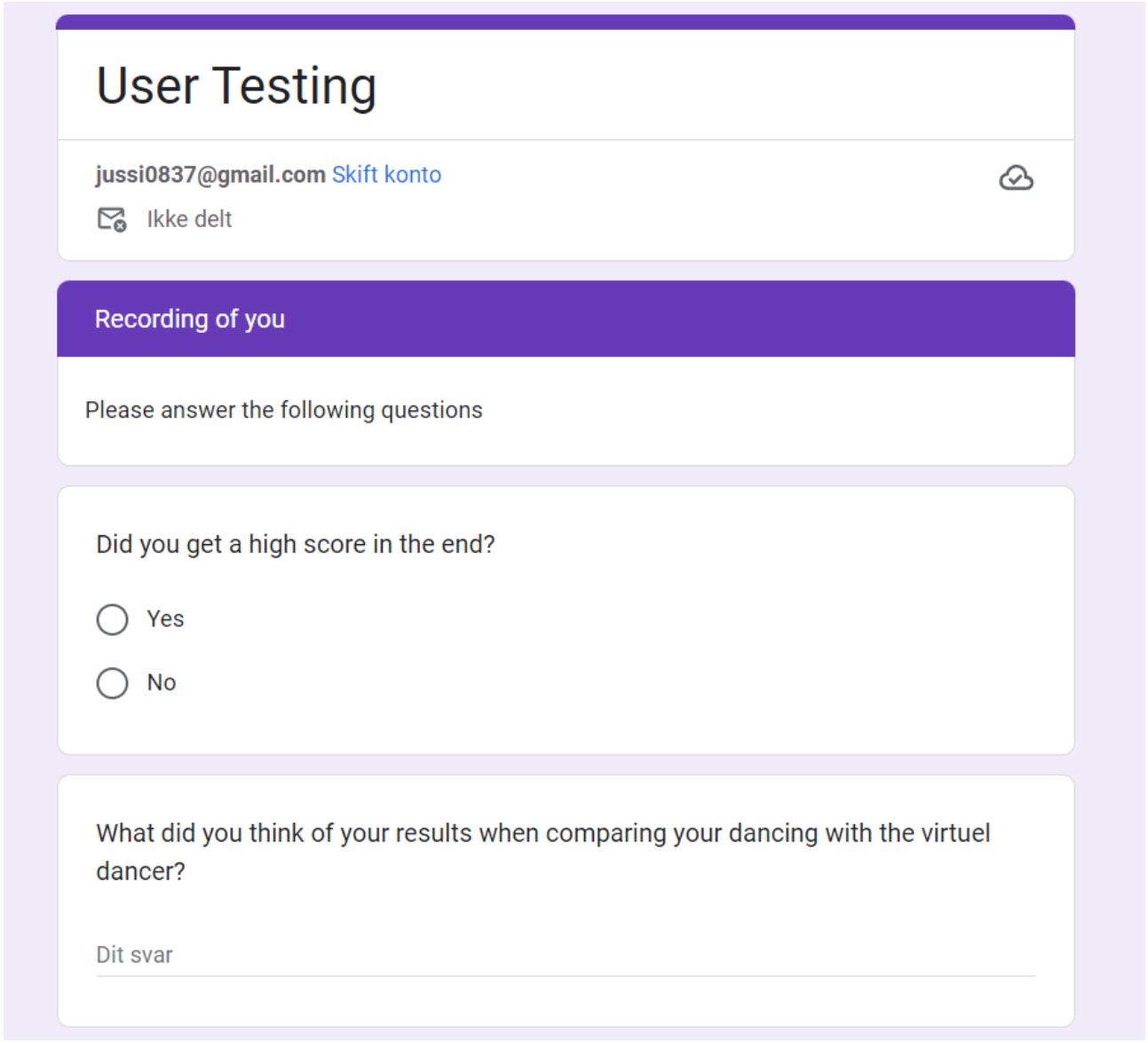
	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly agree

I felt that I learned the step proper from the system

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly agree

It was easy to do the step by myself with music after training with the system

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly agree



User Testing

jussi0837@gmail.com Skift konto

Ikke delt

Recording of you

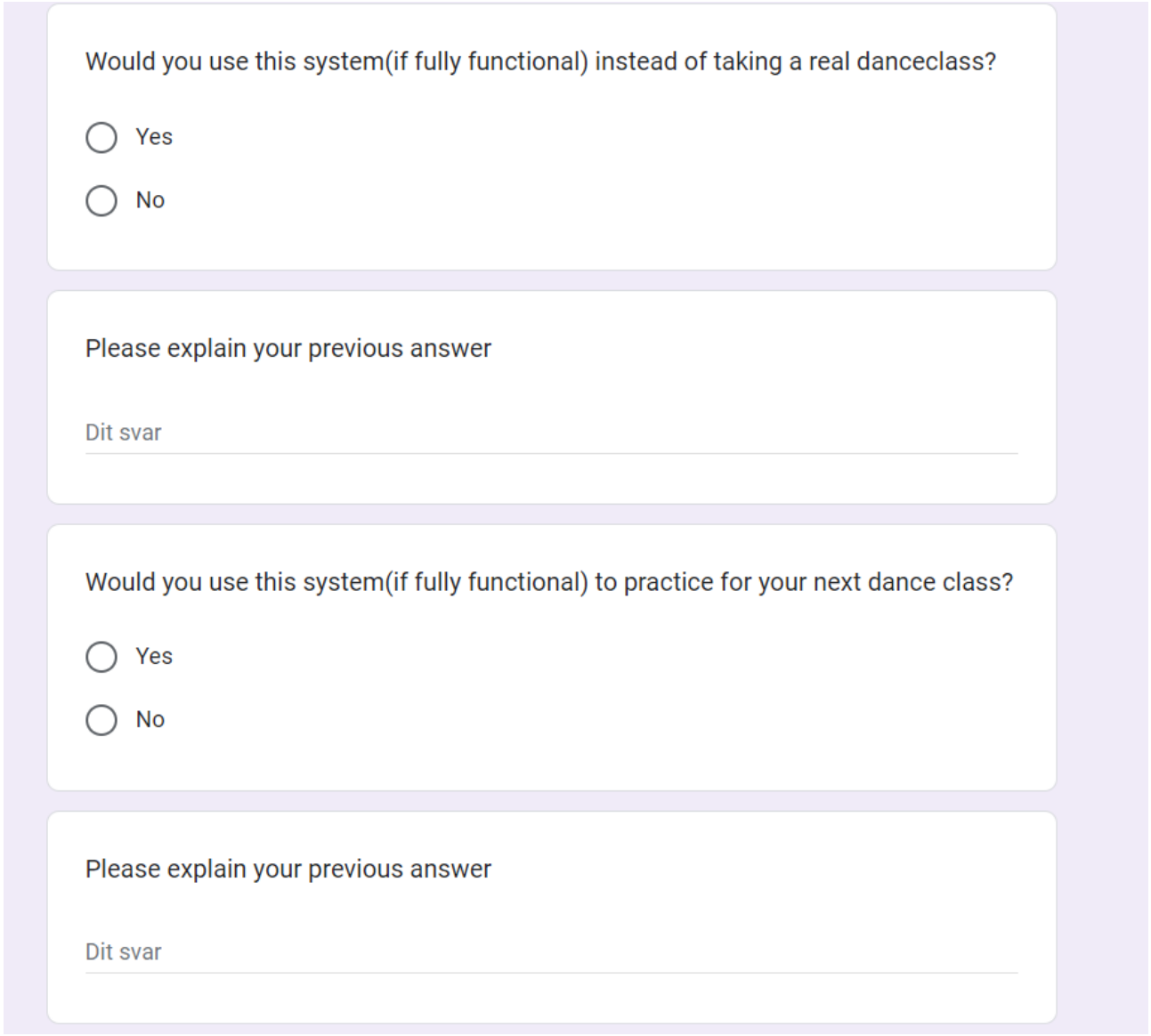
Please answer the following questions

Did you get a high score in the end?

- Yes
- No

What did you think of your results when comparing your dancing with the virtuel dancer?

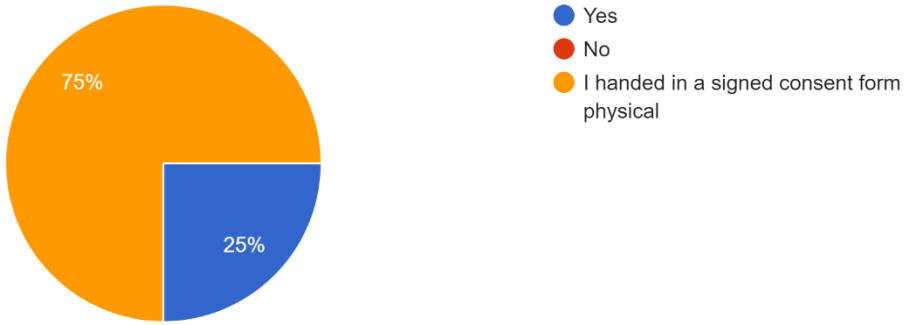
Dit svar



User test results

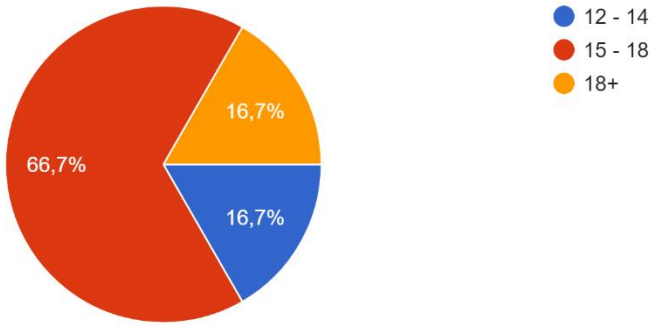
Do you consent?

12 svar



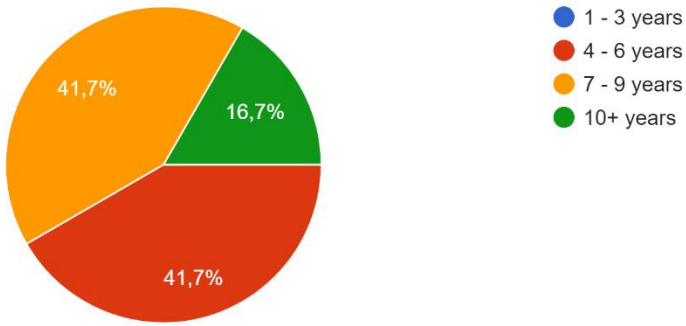
How old are you?

12 svar



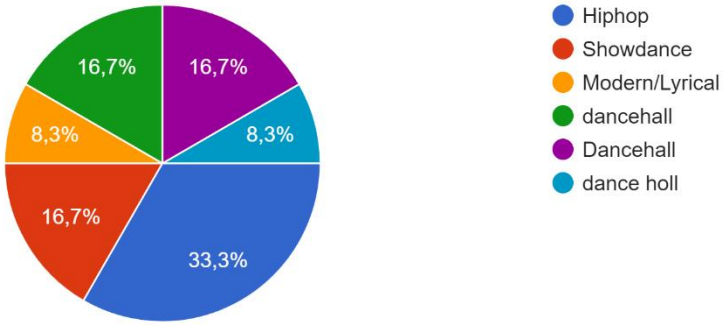
How long have you danced for?

12 svar



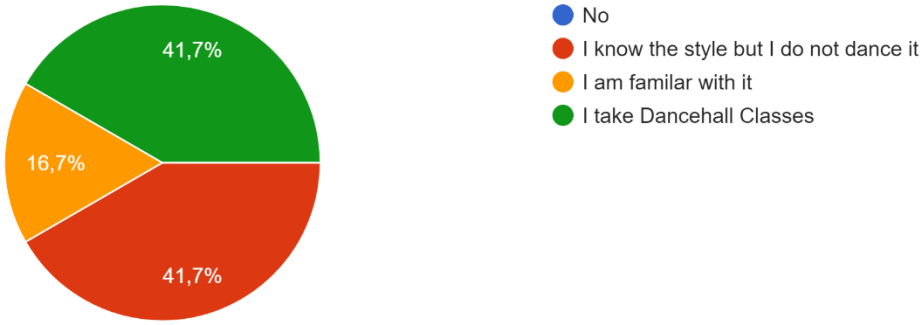
Which dance style do you practice?

12 svar



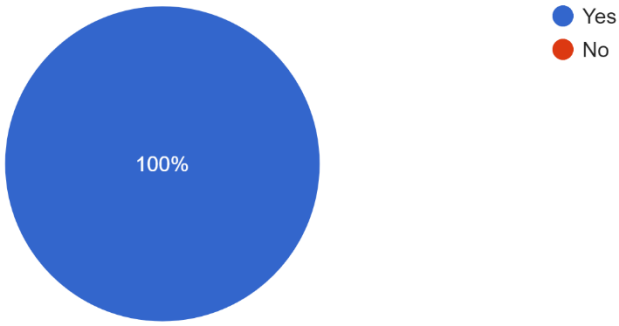
Are you familiar with the dancestyle Dancehall?

12 svar



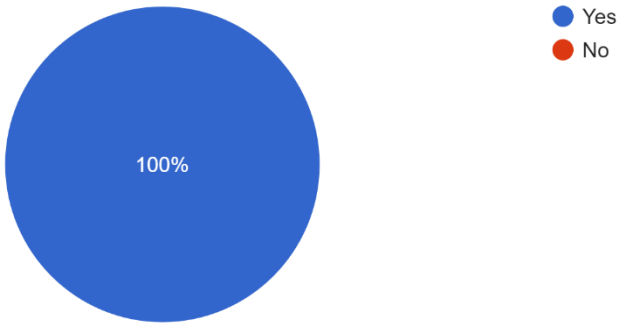
Did the video of the virtual dancer give you an understanding on how to do the step?

12 svar



Did the video of the virtual dancer give an understanding of the speed of the step?

12 svar



How was your overall experience of the video?

12 svar

- good
- it was good and i understand what was going on
- good i like the ider and it was fun
- It was great! The video helped me doing the steps right. Especially the practice video helps a lot before doing the step as you should
- it was very good and very fun to do
- It was great and easy way to learn new steps.
- the virtual dancer made the step overcoming and easy to understand, even though a groove is not something a virtual dancer can give you.
- great

fun

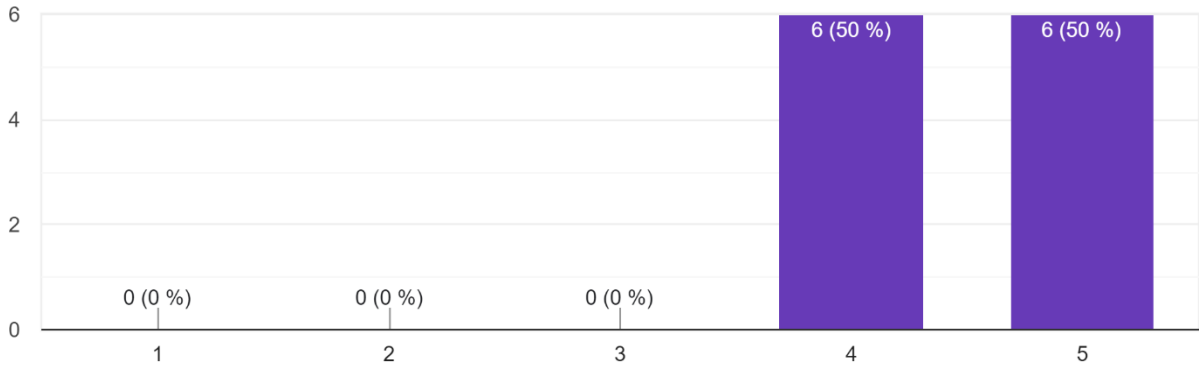
sjov alternativ måde at lære at danse på.

It was great. This way you first get a feel of the tempo and how the moves fit together in a flow. Afterwards you learn it slowly to learn the deatils. It is a great way to learn dancehall steps. Beginners to more difficult.

very nice, you got to get the feel in the start, and then a better understanding of how the steps are done in the slow part

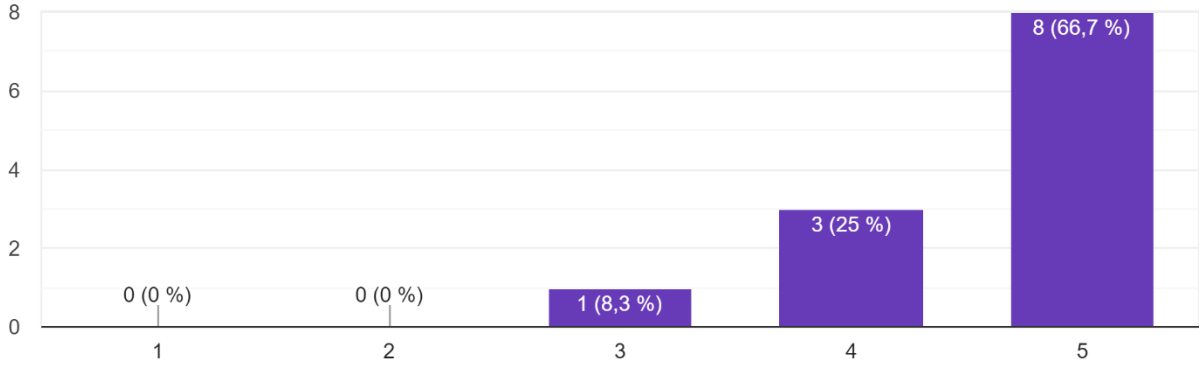
The training session was helpful to learn the dance

12 svar



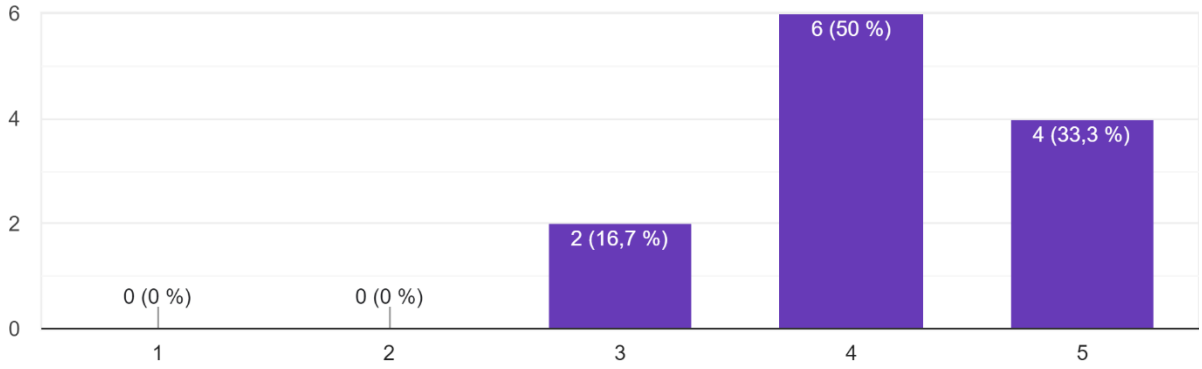
The training session video had a good speed

12 svar



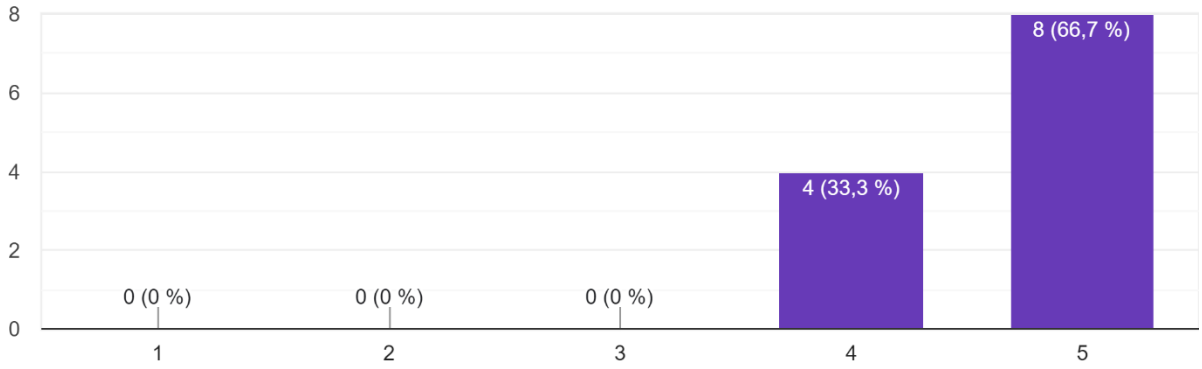
I felt that I learned the step proper from the system

12 svar



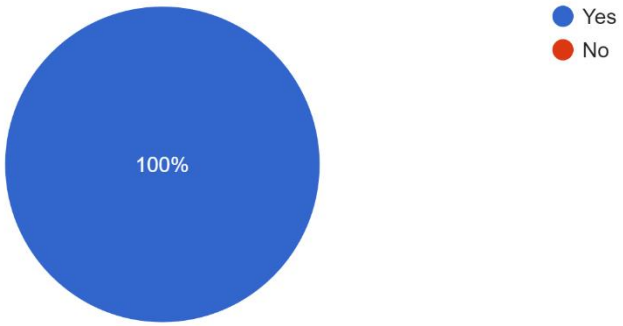
It was easy to do the step by myself with music after training with the system

12 svar



Did you get a high score in the end?

12 svar



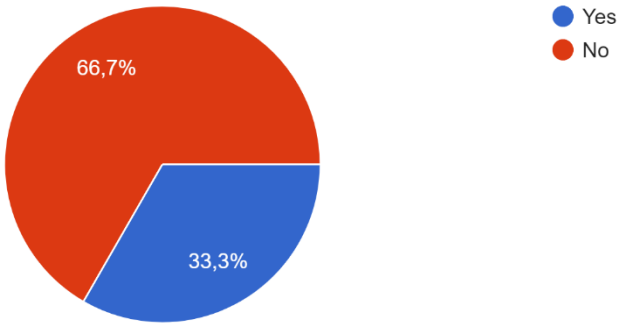
What did you think of your results when comparing your dancing with the virtuel dancer?

12 svar

- good
- it was very fine
- i strte mod in the sisonen but i thik that i have leun a lot and i thikn it was okayyy
- My results was good. The virtual dancer helps a lot
- i think it was very good and also very surprising
- I thought my score was good.
- i looked stupid - but less stupid, than if the virtual dancer had not taught me.
- okay
- Jeg var godt tilfreds med resultatet.
- It looked fun in slowmotion, but it was great to watch me dance with a pro
- well compared to before the slower tutorial

Would you use this system(if fully functional) instead of taking a real danceclass?

12 svar



Please explain your previous answer

12 svar

i would use it but not instead of a real danceclass

becueas its fun to dance with your friendes

i well take but there nothing compris to a rel dance class

It will help a lot of people to dance with a virtual dancer instead of going to danceclasses. Especially because there's a lot of people that feels shy when dancing with unknown people. This would help the shy people a lot.

i would rather take a real danceclass

I like to have a dance teacher, but for new dance steps i think it will bae helpful.

i'm old school, and have been dancing since i was four. a computer can't make up for a teacher.

i think its good for practice but nothing beats in human classes

i like to have a teacher so theres always help and i like to have freinds on my team

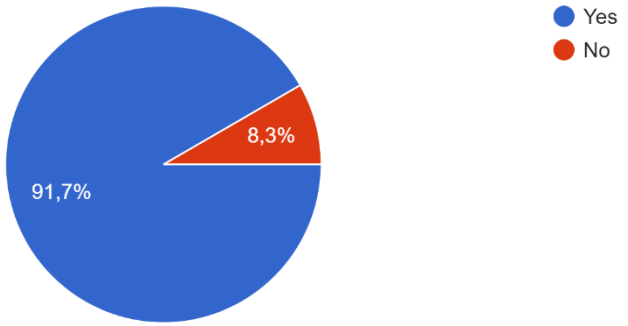
Jeg lærte dansen rigtig fint, men det er trods alt stadig bedst lært i virkeligheden.

It was a maybe. I have a great dancehall teacher, but it could help outside classes.

you can do it in yout own tempo and it is usefull

Would you use this system(if fully functional) to practice for your next dance class?

12 svar



Please explain your previous answer

12 svar

yes

becueas you can aalways lean thing

is lik yes and no becues i love to take a class with pepoel but i wuden mind it becues i likt it

If this was a fully finished game with lots of different dance styles and moves, it would be quite fun to use this virtual dancer

it could be nice to be more prepared for the class

if it is a whole coreography i think i will, but if it's only steps i probably wouldn't.

it's a great way to learn hard steps.

i like how simple it was

its precies and good

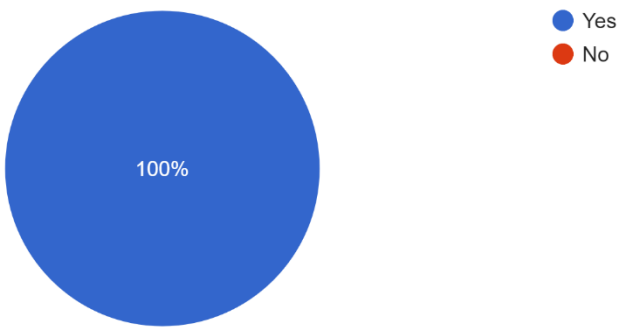
Rigtig godt program til ekstratræning alene, og som forberedelse til en rigtig dansetime.

That would be helpful

very good way to prepare for a class or make sure you understood the steps corectly

Would you use this system(if fully functional) to learn moves from new dancestyles you do not take classes for?

12 svar



Please explain your previous answer

12 svar

yes

beavare to lean thing you dont know

yes i well

When you're new at something, it is comfortable to learn from a virtual dancer before going to dance lessons

yes because i don´t go to dancehall classes yet

it would be a good system to learn new dancestyles and new steps.

easy way to learn new moves you might not have the courage to take a class in before knowing the basics.

it is a good way to try out new dancestyles

its cool if you sudently have to learn a new dancestyle that you know a few steps but also the vibe

Giver en god ide om hvilken stilart du går ind til.

Yeah it is great with different styles

i dont know dancehall well but found it usefull and feel like i learned something

Any last comment?

8 svar

i like it

no i love it it was fun

i like it and you cloud see what the dancer was dogingen

Great project :)

it was very fun

Pisse sjovt

:)

good game

Likert scale Statistics Calculations

Questionnaire											
Question 1	Results	Significant	Question 2	Results	Significant	Question 3	Results	Significant	Question4	Results	Significant
	Mean	4,5		Mean	4,4		Mean	4,17		Mean	4,67
	Pop mean	5,21		Pop mean	3,99		Pop mean	3,76		Pop mean	4,39
	Variance	0,27		Variance	0,52		Variance	0,53		Variance	0,24
	Z	-33,67		Z	-16,4561		Z	-196,439		Z	-307,12
	p	0,00001		p	0,00001		p	0,00001		p	0,00001
	Median	4,5		Median	5		Median	4		Median	5
	STD	0,52		STD	0,73		STD	0,73		STD	0,49
	Mode	5, 4		Mode	5		Mode	4		Mode	5

System scores

Tester	Easy	Medium	Hard	Dance 1	Training	Error	Final	Error	Dance 2	Training	Error	Final	Error	Dance 3	Training	Error	Final	Error	Time Spen
Test 1	x	x		Easy	45%	35%	70%	30%	Medium	70%	20%	60%	30%	N/A					20 min
Test 2	x	x		Easy	51%	32%	92%	12%	Medium	38%	28%	68%	22%	N/A					22min
Test 3	x	x	x	Easy	49%	20%	72%	12%	Medium	95%	23%	95%	23%	Hard	93%	8%	96%	10%	28min
Test 4	x	x	x	Easy	79%	16%	81%	13%	Medium	91%	10%	95%	19%	Hard	89%	5%	91%	5%	25min
Test 5	x	x	x	Easy	42%	33%	51%	32%	Medium	82%	10%	86%	20%	Hard	65%	10%	75%	30%	19min
Test 6	x	x		Easy	94%	16%	95%	10%	Medium	92%	14%	96%	16%	N/A					18min
Test 7	x	x		Easy	74%	18%	68%	23%	Medium	84%	19%	83%	23%	N/A					18 min
Test 8	x	x		Easy	92%	13%	86%	15%	Medium	94%	13%	94%	16%	N/A					19min
Test 9	x	x		Easy	72%	5%	82%	20%	Medium	95%	14%	94%	23%	N/A					20min
Test10	x	x	x	Easy	23%	30%	70%	20%	Medium	45%	80%	58%	40%	Hard	54%	43%	74%	32%	25min
Test11	x	x	x	Easy	43%	50%	60%	42%	Medium	95%	5%	95%	10%	Hard	97%	19%	95%	9%	27min
Test12	x	x		Easy	81%	21%	75%	10%	Medium	84%	11%	95%	10%	N/A					24min

System score statistic calculations

Easy	Training	Error	Final	Error	Medium	Training	Error	Final	Error	Hard	Training	Error	Final	Error
Results	Significant	Significant	Significant	Significant	Results	Significant	Significant	Significant	Significant	Results	Significant	Significant	Significant	Significant
Mean	62,08	24,08	75,17	20,67	Mean	80,41	20,58	84,92	21	Mean	79,6	17	86,2	17,2
Pop mean	49,23	17,16	67,93	14,3	Pop mean	69,28	9,4	76,68	16,32	Pop mean	-24,68	3,47	76,73	6,02
Variance	516,3	149,9	163,97	126,79	Variance	387,17	390,63	211,9	68,36	Variance	359,8	238,5	117,7	162,7
Z	1,95955	1,95887	-181,7	-3,76351	Z	1.96063.	0,00508	-570,652	-67,4971	Z	12,29293	1,95902	-494,488	-69,7827
p	0,025	0,025	0,00001	0,00008	p	0,025	2,57355	0,00001	0,00001	p	0,00001	0,025	0,00001	0,00001
Median	61,5	20,5	73,5	17,5	Median	87,5	14	94	21	Median	89	10	91	10
STD	22,72	12,24	12,8	11,26	STD	19,68	19,76	14,56	8,27	STD	18,97	15,44	10,8	12,76
Mode	N/A	16	70	12, 10, 20	Mode	95	10, 14	95	23	Mode	N/A	N/A	N/A	N/A