



UNIVERSITY OF CAPE TOWN

DEPARTMENT OF COMPUTER SCIENCE



CS/IT Honours Final Paper 2021

Title: Video Annotation as a Tool to Supplement in-person
Dance Classes

Author: James Kriel

Project Abbreviation: SALSA

Supervisor(s): Maria Keet

Category	Min	Max	Chosen
Requirement Analysis and Design	0	20	15
Theoretical Analysis	0	25	
Experiment Design and Execution	0	20	
System Development and Implementation	0	20	20
Results, Findings and Conclusions	10	20	15
Aim Formulation and Background Work	10	15	10
Quality of Paper Writing and Presentation	10		10
Quality of Deliverables	10		10
<u>Overall General Project Evaluation</u> (<i>this section allowed only with motivation letter from supervisor</i>)	0	10	
Total marks		80	80

Video Annotation as a Tool to Supplement in-person Dance Classes

James Kriel
Computer Science Honours
University of Cape Town
krljam001@myuct.ac.za

ABSTRACT

Dance classes in South Africa have typically comprised of in-person learning as the only interaction that a student would have with their teachers. This represents a possibility for issues if someone cannot attend classes or as the pandemic has shown, in-person contact becomes impossible. As such paper presents the development of a mobile video annotation application to supplement traditional in-person dance education. The annotations were used to provide a way for teachers to provide feedback on student-submitted videos and to allow students to take an annotation-based quiz to test their knowledge of the techniques of the dance. Evaluations were conducted on the usability of the tool from both the student and teacher perspectives. The results conclude that Video Annotation displays promise in both the feedback and quiz formats and would benefit from subsequent longer-term studies to observe its effect on students when in use.

CCS CONCEPTS

• **Annotations** → Video Annotations; Annotations for Dance; • **Participatory Design**;

KEYWORDS

Dance Education and Technology, Video Annotations

ACM Reference Format:

James Kriel. 2021. Video Annotation as a Tool to Supplement in-person Dance Classes. In *Proceedings of ACM Conference (Conference'17)*. ACM, New York, NY, USA, 17 pages. <https://doi.org/10.1145/nnnnnnnn.nnnnnnnn>

1 INTRODUCTION

At present, most social dance classes taught in South Africa focus on the traditional and mimetic methods [3, 13]. These methods are based upon the students receiving instructions from the teacher and mimicking the movements of the teacher respectively. These methods have and do still work but as the world becomes more complicated due to factors such as the Covid-19 pandemic, additional resources are required to help supplement the social dance class methods of teaching.

Due to the use of the traditional and mimetic methods, a common issue of social dance classes today is that the teacher will spend the majority of a classes time teaching the sequence of steps and getting the students to follow along. This then leaves very little time for the teacher to observe students attempting the steps themselves and provide feedback. Therefore, this project aims to provide a video annotation tool that will allow dance students to submit videos of

their dancing to their teacher who can then annotate the video with feedback allowing the student to continue to improve and learn at home. Additionally, the application will alleviate the teaching load in the classes by implementing annotation-based quizzes that will allow students to learn the technique of the dance at home before attending the lesson.

Existing literature [3, 6, 7] highlighted the need for a custom dance annotation vocabulary to be implemented through co-development with the dance instructor who will make use of the application due to the need to structure the feedback in a manner that is suitable to the dance style.

The paper is structured as follows: Related Work: Section 2, Requirements Analysis and Design: Section 3, Software Development Methodology: Section 4, Software Implementation: Section 5, System Evaluations: Section 6, Results: Section 7, Discussion: Section 8, Conclusions: Section 9, Future Work: Section 10 and Acknowledgements: Section 11

2 RELATED WORK

This section provides information on prior work done with regards to dance education technologies, mobile video annotation systems and co-design methods.

2.1 Theory of Dance Education

Based on findings from Raheb et al. and Cisneros et al. [3, 13] four main approaches have been identified for teaching dance. These are the Mimetic, Traditional, Generative and Reflective Methods. In social dancing it is more likely that teachers will be working with larger groups that do not practise as regularly and so will prefer the Mimetic and Traditional methods. As such only those methods will be elaborated on.

The Mimetic method focuses on a student imitating the movements of the teacher after a demonstration and receiving feedback. The approach has also been referred to as the "see and do" approach. The Traditional method focuses on the teacher making all decisions for the student and greatly emphasizes the students as being either right or wrong. There is a large focus on accuracy and precision in this method. It is also referred to as command style teaching.

2.2 Video Annotations for Dance Education

2.2.1 Annotations in Education. Very little work has been done to study how annotated videos can improve a student's dancing, but studies have shown the benefits of annotated content in other mediums. Suhre et al. and Po-Sheng et al. [2, 15] showed that creating annotations while engaging with video content helped to increase students' performance by increasing their cognitive load and learning satisfaction. In both studies, the experimental group, creating

annotations, outperformed the control group on tests relating to the topics.

A study by Sheng-Shiang Tseng [16] used a control and experimental group to show that the use of "teacher" annotated videos could increase the learning engagement of students and increase the cognitive engagement while having no effect on the emotional engagement with the material. These studies highlight the ability of video annotating to increase a students engagement with the content being displayed in a video and aid in the retention of the information.

2.2.2 Annotations in Dance. Video Annotations in Dance Education systems have been used for a variety of reasons. Projects such as WhoLoDancE and DanVideo [3, 11] made use of video annotations to provide a richer language with which to query dance videos in a database improving how easily students could find dance pieces to learn from, although the primary purpose was for the study and preservation of the dance pieces.

The study by dos Santos et al. [6] made use of annotations to allow a dance educator to provide feedback on student-submitted videos through a web application and proved the usefulness of this feedback in its scenario. The study by Lu-Ho Hsia and Gwo-Jen Hwang [8] displayed the use of annotations for university dance classes using a flipped classroom method. This study demonstrated that students who annotated videos of a dance lesson to identify crucial aspects and practised their analysis before the in-person class were able to outperform a control group in the quality of dancing they learnt. This highlights the importance of engaging with video content when learning which annotations can facilitate.

The study by Lu-Ho Hsia and Gwo-Jen Hwang [8] also allowed for more time in the classroom to be devoted to the teacher watching the students perform the dances and provide feedback rather than needing to demonstrate and teach the steps for most of the class time. Only the study by Lu-Ho Hsia and Gwo-Jen Hwang [8] was implemented as both a web and mobile application while all the other projects were implemented as web-based only [3, 6, 11] which limited their portability according to participants in the studies.

2.2.3 Annotation Vocabulary. A majority of the studies conducted using video annotation for dance have developed a custom vocabulary for use in the annotation process [3, 6, 7, 11]. This vocabulary allows annotations to be grouped into broad categories with the feedback then entered under this label helping to organize annotations and create an easier to understand interface. The vocabularies also accommodate additional detail such as which body part is being referred to by the annotation, who the dancer being annotated is, the performance's location, the song playing and customizing the start and end time for when the annotation applies [3, 7, 14]. As an example of how the vocabularies are created, the Web-based Movement Library (WML) [7] and WhoLoDancE [3] made use of three main categories of movement descriptors which are:

- Movement Quality Descriptors
- Movement Principles Descriptors
- Action Descriptors

WML further specified these categories as follows:

Movement quality descriptors relate to movement qualities such as

fluid, rigid, light etc.

The movement principles descriptors are related to Movement principles, high-level concepts that are used across all dances regardless of genre, such as symmetry, directionality, rhythmicity, coordination, etc.

The action descriptors consist of a list of basic actions such as jump, turn, step, arm gesture etc.

The idea of keywords was also used by dos Santos et al [?] and they generated the following keywords by recording a think-aloud session of dance teachers critiquing videos of their novice students:

- Synchronicity
- Weight Transfer
- Limb/Join Movements
- Quality of Movements
- Posture
- Gaze

Synchronicity and Weight transfer represented 67% of the comments and so were then used to generate a list of "Skills" which were used as the categories for annotations. The Skills generated were as follows:

- Rhythm: dancing with consistent rhythm
- Pause: pausing at the right time
- Synchrony: moving with the beat of the song
- Time between movements
- Weight Transfer
- Step Size
- Dance Jumping: to be avoided
- Stepping Strongly: to be avoided
- Hip Movements: ensuring it is done correctly

Annotations could then be selected from one of these categories, which were colour coded to aid in ease of use, and added to the video. The input from the teachers to generate the keywords highlights the importance of co-design, specifically in the vocabulary's development.

2.3 Annotation Systems on Mobile

Due to the different constraints between web-based applications and mobile, studies have identified primary concerns for mobile annotation systems as follows [4, 5]:

- Intuitive Addition of Annotations
- Virtual Keyboard Input
- Display in different Screen sizes
- Variable Screen Orientations
- Duration of Display of Textual Annotations
- Video Selection
- Annotation Navigation
- Multiple Annotations Displaying Concurrently

Cunha et al. [5] found positive results from users by making use of a simple interface allowing users to pause or play a video and then type any comment and click an "Add" button to add the annotation. MoViA [4] made use of a similar display with the additions to allow annotations to take multiple forms aside from text only.

For navigation they made use of studies from Hürst et al. [9, 10] to determine that a thumbnail of 90 pixels provides good recognition results within small screens to decide the size of the image to

accompany the annotation in the user interface. Limited storage on mobile devices also presents a concern, thus Cunha et al. and MoViA [4, 5] made use of the Simple XML library to generate and manipulate the annotations stored within XML files as Simple XML requires little space while offering high performance.

3 REQUIREMENTS ANALYSIS AND DESIGN

This section will focus on the requirements of the project and an initial high-level design of the project solution.

3.1 Requirement Gathering

The requirements for this project were based on improving the experience of social dance education through the use of technology. The project began with an initial meeting with the project supervisor to gain a basic understanding of the problem and an introduction to the literature surrounding the topic. After the initial meeting, additional requirements were sourced through independent research into the surrounding literature. The existing literature revealed common issues within the dance education community along with prior projects that had been undertaken and their results. From the meetings and existing literature, we decided that the best solution would be a Dance Education Platform into which various components could be added. This paper focuses on the development of a Video Annotation component to be used by:

- (1) Teachers to annotate student-submitted dance videos with personalised feedback
- (2) Teachers to annotate videos to create quizzes to teach students the basic theory of the dance
- (3) Students to receive the personalized feedback
- (4) Students to take the annotated quizzes

Based on these desired features the functional requirements of the video annotation component are as follows:

- Provide a custom vocabulary with which to annotate dance videos
- Provide a basic video playback application
- Editing/Deletion of annotations
- Ease of navigation between annotations
- Creating a quiz using an existing video
- Completing a quiz and seeing feedback in the form of a score
- View the annotated feedback videos in a displayable form

The custom vocabulary was developed during video meetings with one of the educators from Evolution Dance Studio to ensure it would be personalized and meet the requirements of their specific style of teaching.

Additionally, best practices regarding user interface design will be adhered to as specified by the heuristic guidelines.

The videos used to populate the application for testing and evaluation purposes are sourced as original videos from the Evolution Dance Studio.

3.2 Stakeholders

As this project was being undertaken as a software development task it was important to determine who the stakeholders in this project were. We determined the stakeholders to be the educators

and students of the Evolution Dance Studio and the project supervisor.

3.3 System Architecture

Figure 1 below displays the basic architecture of the application and highlights the core components. The VideoFiles Module is used to store all the data on the videos themselves. The Annotation Module is responsible for the creation, editing, deleting and saving of the annotations themselves. The Storage Module is used to load and save Annotation Module objects to the cellphone's SD card. The core framework for constructing the User Interface and facilitating interaction with it is abstracted into the Android Studio Framework Module as this is accomplished using predefined classes and the additional code added to these classes will be discussed in Section 5. As database design was not part of the scope of this project the storage of the annotations and videos will be done using folders on the emulator's SD card component.

A class diagram is included in the Appendix. This will be referenced and elaborated on in Section 5.2 to describe how the components of the application interact.

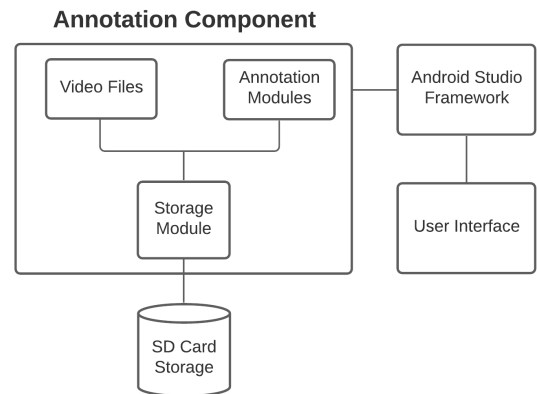


Figure 1: Architecture Diagram for Video Annotation Tool

4 SOFTWARE DEVELOPMENT METHODOLOGY

The project will be implemented using an agile development methodology. Agile software development is defined as a blanket term for a set of frameworks and practices based on the principles expressed in the Manifesto for Agile Software Development [cite stuff here]. This project will make use of a basic iterative cycle from the agile methodology umbrella. An iterative cycle offers a process that reaches the end goal in a series of improving delivery cycles allowing for increased focus on sections of the development instead of the whole project at once. Iterative development is intensely focused on the high priority features of a software project which is suitable for this project due to the limited time-frame in which development will take place. Additionally, due to the limited time-frame it was only possible to have two client demonstrations prior to the evaluations with one being a conceptual discussion and the second a practical application in-progress demonstration.

4.1 Work per Iteration

This subsection will describe the work that was accomplished with each development iteration.

4.1.1 First Iteration. The development of video playback and navigating through all videos in the application.

4.1.2 Second Iteration. The development of the framework of the annotations in the form of the annotations objects, the creation of annotations within the application, the storing and loading of annotations objects and the creation of a custom annotation vocabulary were implemented.

4.1.3 Third Iteration. The planned work was to implement the editing, deleting and viewing of the annotation content. Editing was successfully implemented during this iteration with viewing delayed as it was less of a priority than working on the deletion during this iteration. Deletion was also delayed due to complications that meant the feature couldn't be completed fully within the iteration. Additionally, the development of a quiz creation feature was introduced into this iteration when the viewing and deletion were delayed.

4.1.4 Fourth Iteration. The development of taking a quiz, annotation viewing and annotation deletion were implemented.

4.1.5 Fifth Iteration. The refactoring of code to improve performance and the overall user interface design was implemented.

4.1.6 Sixth Iteration. The implementation of feedback acquired from the evaluations and additional refactoring will be implemented. For documentation purposes the implemented feedback will be Next and Previous arrows to facilitate easier movement between annotations.

5 SOFTWARE IMPLEMENTATION

Before the development of the application began, the main deliverable was established for each cycle. By establishing these deliverables early the project will be able to stay on time and keep the work done within scope to avoid an issue with scope creep appearing during development.

The main deliverables were derived from the functional requirements listed in Subsection 3.1.

5.1 Development Platform and Programming Language

The video annotation component was developed in Android Studio using the Java programming language. A minimum API level of 24 was chosen as this would allow the application to be used on approximately 80% of all android devices.

Both Java and Android Studio were chosen due to prior experience working with them. This allowed development to proceed faster than if a new language or environment needed to be learnt which was decided to be preferable due to the short development time.

5.2 Class Structure and Libraries

Figure 4 in the Appendix displays the class structure of the four core classes. The VideoFiles class represents the VideoFiles module from Figure 1 while the AnnotationWrapper, Annotations and

QuizQuestion classes represent the Annotation Module. The VideoFiles class functions as a holder for information on the videoFiles and is primarily used to load videos into the video player using the path variable and storing the duration of the videos for display purposes.

The AnnotationWrapper functions as a holder for all the Annotations linked to a specific video. The association to the relevant video is created by using the id of the videoFile as the id for the wrapper. A hashmap was used to store the Annotation objects with the Integer key representing the Annotation objects id. The AnnotationWrapper classes methods handled the creation, editing and deletion of Annotations in the hashmap.

The Annotations class held all information about an annotation at a time point. The Annotation object could optionally either be used for feedback or for creating a Quiz Question, this would result in either the content or quizQuestion variable being null respectively. The QuizQuestion object was used to abstract the storing of the additional variables needed for the quiz from the core Annotation structure as this was originally a secondary function rather than the core focus of the project, but this also helps support modularity for the annotations should other features be desired in the future.

Figure 5 in the Appendix displays the class structure of standalone objects used to facilitate additional features in the application. The StorageModule is used for providing checks on the availability of external storage, saving and loading annotations and the thumbnail images associated with them. The HelperTool class was created to house methods that would not make sense to include in other classes to keep the separation of concerns in the core classes. This class manages conversions of time representations from milliseconds to a min:sec format, finding the correct AnnotationWrapper from a VideoFile id, deciding whether a new AnnotationWrapper should be created or if there is an existing one to load and creating the bitmap images from a frame in the video to function as the thumbnails. Both the HelperTool and StorageModule methods are declared as static to reduce overhead resources by needing to instantiate the class to use its methods. The QuizAnswers class is used to temporarily track which questions have been answered during the use of a Quiz but is never stored.

The core media player used was a plugin library for Android Studio called ExoPlayer. The ExoPlayer library contains many features that make it more suitable for this project, primarily the ease with which aspects can be customized allowing for extensions and upgrades to the application in the future and its incorporation of a built-in video control system which helped reduce development time on the video player.

Conversion between AnnotationWrapper, Annotation and QuizQuestion objects to XML files for storage and vice versa was handled using Simple XML. The decision to use Simple XML was based on testing other libraries and also the recommendations for it from the prior literature due to its lightweight and high-performance nature.

Table 2 displays the name of the Android Studio classes and lists their core functions. Classes within such as AnnotationDetailsFragment, AnnotationDetailsFragmentEditing, QuizCreationFragment

and QuizCreationFragmentEditing all perform very similar functions. The main reason for the creation of an almost duplicate "Editing" class was due to time constraints and issues in programmatically creating a delete button within the original views. To ensure functionality would be delivered on this approach was taken.

5.3 User Interface Design

The User interface was designed following Nielson's 10 Usability Heuristics [12]. A core heuristic is the visibility of the system status allowing users to always know what is going on in the system. To this effect, all buttons and controls have been labelled and after functions have been executed either a screen will change or a Toast message or AlertDialog will be displayed. The Toast messages are demonstrated in Figure 10 and were also used when deleting an annotation, informing a teacher if a required section for feedback or quiz creation was empty and to display Permission Granted when loading up the app in regards to access to external storage. AlertDialogs were used within the Student Quiz to allow a user to continue after seeing a hint, Figure 18, and to display their results after finishing a quiz, Figure 21.

All controls for playback of a video were made to be similar to real-world playback controls and appear as the standard across other applications.

The video playback screen looks similar across all four sections of the app to encourage recognition over recall so that once a student has encountered a quiz, using feedback will be simply and vice versa. The same also applies to teachers regarding creating feedback or quizzes.

Overall, the user interface was designed to resemble current mobile applications as close as possible to increase a user's familiarity with it and aid in the ease of use.

6 SYSTEM EVALUATIONS

The system evaluations will be conducted through user evaluations to determine the usability, explorability and suitability of the application to solve the problem.

6.1 Participant Recruitment

The participants will be recruited from within the Evolution Dance Studio. Due to the focus on two components using the same annotation base, one providing a method for teachers to give feedback on student-submitted videos and the other allowing students to test their knowledge of the dance techniques, there will be two participant groups. The first group of participants will be comprised of the two dance teachers from Evolution Dance Studios and the second group will comprise of 6 to 8 students of the Evolution Dance Studio. The student participants will be recruited by the educators at Evolution Dance Studio and all participants will be emailed an informed consent letter detailing the nature of the evaluation, what is expected of them and what their rights are with regards to their participation.

6.2 Evaluation Procedure

This section will address all universal aspects of the evaluation procedure across the two groups from the basic setup, the online

rules and the structure of the process. Specific questions and tasks will be discussed in a subsequent section.

6.2.1 Online Requirements. Due to Covid-19, all project evaluations will be conducted online to ensure the safety of everyone involved in the research. To facilitate this online approach the evaluations will take place over a video call and participants will be required to make use of a laptop with AnyDesk, a remote desktop, software installed on them. This software will allow the participant to take control of the laptop running the application and will keep all requirements for hardware to run the application within the project team. As there may be issues with everyone being able to access a laptop and install the AnyDesk software we will make a laptop with the software pre-installed available via our Supervisor for the participants to use after a dance class.

6.2.2 Evaluation Structure. The evaluation will be structured in three phases:

- An introductory session
- A task session
- A post-evaluation survey to be completed on their own time

During the first two sections, with participant consent, the video-call of the evaluation will be recorded and the participants will be encouraged to speak aloud their thoughts as they interact with the application. This will allow us to capture expressions and problems they may not remember by the time of the questionnaire and interview and thus gives us a fuller representation of their experience. The beginning of the Introductory Session will be done as a pre-recorded video to ensure all participants receive the same instructions. After the introduction, participants may ask any additional questions they may have before they proceed to the 5 minute exploration time. The exploration time will allow participants to use the application themselves without any assistance to determine its explorability.

The Task Session will be used to determine if the core features of the application can be easily understood and interacted with by a participant. These task lists will be predefined before the sessions and will not change between participants. Though there will be two different task lists for the two different participant groups. The content of the Task lists is specified in Sections 6.3 & 6.4.

The post-evaluation survey will be used to get the final impressions of the participants on the application. The questions will be given in long-form, open-ended questions, short questions and Likert scale responses allowing for a mixture of qualitative and quantitative data to be obtained based on the participant's experience. The survey will be hosted on one of the online survey platforms and a link will be distributed to the participants via email or instant messaging as soon as they have completed the first two stages of the evaluation.

6.3 Teacher Specific Instructions

The dance educators will undertake the evaluations one at a time. The focus of this evaluation will be the Student Feedback Annotations and the Quiz Creation features.

The specific task list for the teachers will be as follows:

- (1) Navigate to the Feedback Creation Tab
- (2) Open a Video and Create a new Annotation

- (3) Update an Annotation
- (4) Delete an Annotation
- (5) Navigate to the nth Annotation
- (6) Navigate to the Quiz Creation Tab
- (7) Open a Video and Create a new Quiz Question

Following the completion of the first two stages of the evaluation the teachers will undergo the student evaluation as well, time permitting, to be able to give feedback on how well they think the presentation of the quizzes and feedback will benefit their students.

6.4 Student Specific Instructions

The students will undertake the evaluations in groups of 2. The focus of this evaluation will be to complete one of the Quizzes and to use one of the created feedback videos. As the students can range from a wide set of backgrounds with varying levels of technical literacy it was decided that it would be best to have them interact with the system in pairs as this would allow them to not only learn by doing but by discussion amongst themselves as well which would encourage better responses than if they were interacting with the system one on one.

The specific task list for the students is as follows:

- (1) Navigate to the Quiz tab
- (2) Open a Video Quiz
- (3) Complete a Video Quiz
- (4) Check a hint
- (5) Check prior answers
- (6) Navigate to the Student Feedback Video tab
- (7) Open a Video and Navigate through the Feedback Annotations

At the end of their evaluation, the student participant's will be offered the option to be given a brief tour of the Teacher's perspective for creating the feedback videos and the quizzes respectively. They may also provide feedback on these in the survey if they choose but unlike the educators, it is not mandatory.

6.5 Post-Evaluation Survey

The initial survey statements will be adapted from the System Usability Scale (SUS) [1] as this provides a strong baseline to cover the general impressions of a user in regards to a system. The adaption of the SUS was to make sure that the statements referenced the type of system I was evaluating and in some cases, elaboration was added to make statements clearer. The SUS statements use a Likert scale response in the form of 1, strongly disagree, up to 5, strongly agree, to elicit feedback from the participants. To calculate the final score of a SUS these results are added with odd-numbered questions contributing their value minus one and even-numbered questions contributing 5 minus their value. This new score is then multiplied by 2.5 to get the overall value of the SUS. The adapted SUS statements are displayed in Table 3 in the Appendix. Additionally, application-specific questions will also be posted to the participants with these divided amongst questions for both groups and questions for only the teachers or students respectively. These questions and Likert scale statements are displayed in Table 4 in the Appendix.

7 RESULTS

The evaluations were run as per the specifications in Section 6 with the exception that the introductory video had to be replaced with a live introduction and explanation due to technical issues with displaying the video over Zoom.

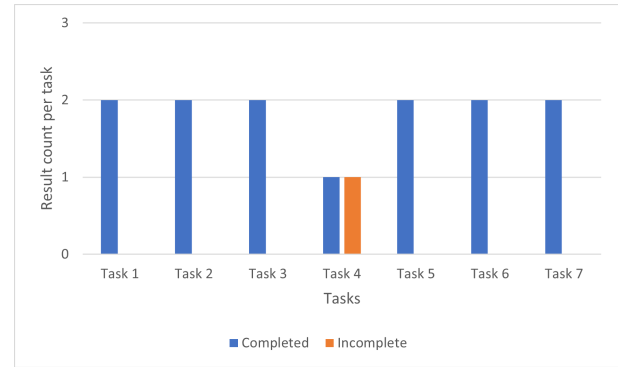


Figure 2: Graph displaying how many Teacher tasks were Complete vs Incomplete for 2 Teachers

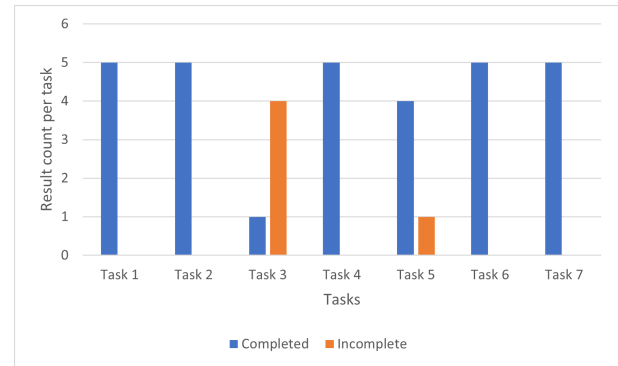


Figure 3: Graph displaying how many Student tasks were Complete vs Incomplete for 4 Students and 1 Teacher

Figure 2 and Figure 3 display how many tasks were successfully completed by within the Teacher and Student task groups respectively. From the graphs we can observe that most tasks could be completed except for Task 4 in the Teacher section and Task 3 in the Student. In Task 4, the participant attempted to remove the content from each possible input rather than using the "Delete" button. Task 3 was incomplete as participants did not realise they had to click "Back" after completing a quiz question to return to the Quiz List and select the next question while Task 5, requiring participants to view past answers was marked as failed due to the participant using the "Android Back Button" that would be part of the Android UI to return to the Quiz List which instead returned the participant to the main screen. Overall, this indicates that the application performed well as the majority of the tasks were completed by all participants. In support of the high amount of incomplete statuses for Task 3 of

the Student tasks was the fact that many students had to ask for assistance in completing this during the evaluation itself, elaboration on the issue will be addressed in Section 8.

Table 5 displays the numerical score given to each of the 10 System Usability Survey questions and Table 1 below displays the final calculated SUS scores.

Participant	SUS Value
P1 (T)	77.5
P2 (T)	67.5
P3 (S)	92.5
P4 (S)	85
P5 (S)	77.5
P6 (S)	95

Table 1: Overall System Usability Scale Values

7.1 Student Specific Survey Section Responses

P3 said "One can review one's movement and get valuable, visual feedback on your technique." and P5 commented, "The student can get feedback from the instructor to improve themselves without being at class." in support of the application providing a good supplemental experience to in-person teaching, while a concern raised by P4 was, "The teachers presence is conditional to learning this discipline. It could be used as support system. An add on."

The reception to the presentation of the teacher feedback was mixed to positive with P3 commenting, "It wasn't clear if the feedback was for the entire video or sections of the video- a la YouTube." while P5 said, "It was simple to follow."

All participants believed the quiz would assist with learning basic theory before classes. P6 and P3 were highly supportive of this feature saying, "Definitely gets you thinking about it from a theoretical perspective before putting it into practice." and "Yes, particularly with respect to terminology and dance lingo." respectively.

The most liked features were varied between participants with one citing the Feedback feature, another the quizzes and one the hint feature within the quizzes.

Overall opinions on the application were wholly positive with P3 calling it, "Very good", P4 referring to it as "Simple and user friendly", P5 saying "I think it has good potential" and P6 calling it "User friendly. Keen to use".

7.2 Teacher Specific Survey Section Responses

P1 was highly positive believing that the application would be able to provide a good supplemental experience to the in-person class while P2 was unsure as how useful the application would prove to be in practice. P1 expressed that, "The annotation would be very useful to students and would give a teacher a good way to interact with people".

P1 advised that, "The feature set is good. I would consider a different lexicon as the labelling is not intuitive." in regards to improvements that can be made to the annotation feature set, while P2 did not believe there were specific additional features required.

Both P1 and P2 believed the feedback annotations could improve

student dancing and could do more with a richer feature set saying, "Yes. The tool would add great value with feedback delivered in a personal and practical way. This could possibly be enhanced to use a start and end time in the video since the context may extend to a series of moves and not just one." and "Yes, They can see themselves doing the step and the teacher giving feedback. And they can refer back to the comments at a later stage." respectively.

P1 was unsure how to comment on the usefulness of the quizzes saying, "I find it difficult to answer this as the idea of quizzing someone on a video is quite a novel idea. This may be more useful if the multiple choice was supported by a free text elaboration on the answer".

The most liked features were the feedback annotation and the fact that annotations were linked to a moment in time in the video.

Overall opinions were wholly positive with P1 saying, "Great effort and certainly something i would pursue to create more value for my students." and P2 calling the application "User friendly". An additional comment provided by P1 regarding the ideas within the application was, "Good effort. The initial requirements were met and some additional features got me thinking about new ways to engage students. Well done".

8 DISCUSSION

This section will discuss the development and evaluation processes, their strengths and weaknesses and the results obtained.

8.1 Application Development

8.1.1 Out of Scope Features. The purpose of this project was to test the usefulness of video annotations as a supplement to in-person dance education on a mobile device. Due to the limited development time, only the core functionality was implemented and the following features that would be included in a mobile application going to market were not developed:

- Uploading new videos to the app
- Organizing videos within the app in folders
- Deleting videos
- Creating accounts
- Sending a video between accounts (student to teacher and vice versa)

This was decided early in development as prioritizing the core educational components and perfecting their back-end systems and user interfaces would allow for better results from the evaluations than adding additional features.

8.1.2 Limitations of the User Interface. Due to time constraints, certain features were not implemented at this time. At the time of the evaluations, the navigation of any feedback or quiz questions from the student or teacher perspective can only be achieved by returning to the list view of all the feedback or quiz items - Figure 16, Figure 12, Figure 10 - rather than being able to go to the next one from within the view of one of the feedback or quiz items, Figure 17. Additionally, issues with implementing the deletion on the listed items, Figure 10, as a popup menu resulted in the Delete button being moved to the Editing fragments, Figure 11 and Figure 15 as discussed in Subsection 5.2.

8.2 Application Evaluations

The live introduction resulted in each session having a different introduction, in the way it was delivered, which has the possibility of additional information being given to subsequent participants as it was learnt what did and did not confuse participants in previous introductions. This could have a minor effect on the perceived usability as additional information would have added context prior participants had to figure out themselves.

Additionally, there were only four participants used for the Student side versus the proposed 8. This came about due to time constraints and the low number of students currently attending classes due to Covid-19. This isn't considered a large issue as due to Covid-19 the number of regular students at Evolution Dance Studio currently stands at 9 students which means that 4 students are still statistically significant to represent the population.

The main weaknesses of the evaluations all related to the need to run them online over video calls as there were technical issues with using AnyDesk at random points in the evaluations. This had the potential to skew participant's views on the usability of the application due to the perceived troubled nature of the evaluations themselves. Based on the results it appears this did not happen, but it is a concern to note.

In the future, it is recommended to attempt to proceed with in-person evaluations instead of online, but should online be necessary then this method is usable. Additional, troubleshooting with fellow team members to find and fix all issues mentioned here would also be recommended.

8.3 Task Completion

8.3.1 Teacher Tasks. The issues with Task 4 and the delete button indicates a failure on the development side to make the delete function immediately apparent. This can be improved by potentially introducing a tutorial into the application.

8.3.2 Student Tasks. This issue with Task 3 stemmed from time constraints during development as mentioned in Subsubsection 8.1.2. This does present an area that can be improved in future iterations and is additional motivation to possibly include a tutorial feature within the different sections of the application when they are first opened.

The issue with Task 5 could be solved by reprogramming the Android UI Back button to only go back one section rather than to the beginning, but this can be investigated further in subsequent evaluations and through design guidelines to decide the best use case.

8.4 System Usability Surveys

When interpreting SUS values the convention is that a score of 68 and above indicates that an application is acceptable and could be shipped at that point. Based on the results in Table 1 the overall trend is that the system is perceived to have a high perceived usability by all except one of the participants. The participant with the lowest SUS score is one of the teacher participants indicating that improvements can be made to the teacher-specific sections as participants P3 to P6 would not have been exposed to those sections and thus this can explain their higher scores compared

to P2. Additionally, the highest teacher participant, P1, score was 77.5 which matched the lowest score of the student participants, P5, which supports that by seeing more facets within the application which are also more involved that the perceived usability decreases. Overall, the System Usability Survey was a strength of the evaluations as it has provided a quick solution to acquire accurate and industry-standard data with little time and resources. Additionally, the results have shown an overall positive trend in regards to the usability of the application which would indicate that overall the development goals have been successful.

8.5 Student Specific Survey Responses

The feedback from the student-specific survey responses mainly provides positive and constructive feedback which can be used to further development. Most of the participants did believe the application would provide a good supplement to in-person teaching providing a metric of success as this was one of the core goals to achieve in the app's development. The one participant who was concerned did say mention that the app "... could be used as a support system. An add on.", which is the goal of the application, but the confusion may indicate that the application may appear to aspire to replace in-person teaching and this should be addressed. The quiz feature received positive feedback with no mentions of improvements that could be made aside from those drawn from the task sessions themselves. Similarly, the feedback feature was received positively but it was noted that it was unclear whether the feedback was for the entire video or sections of it. This issue supports the possible need for a tutorial upon an initial login and supports including annotations over a period of time rather than a moment in time as mentioned in Section 8.6. Overall, the students received the app positively and believed there was potential within it.

8.6 Teacher Specific Survey Responses

The teacher-specific survey responses also provided mostly positive results with additional pieces of constructive feedback. The application was received positively although one participant was not certain of how effective it would be in practice. This would encourage the use of a longer-term study to discover if demonstrable improvements can be seen in students. Regarding quiz and feedback creation, one participant found the current lexicon for labelling to not be intuitive which can be seen in Figure 7. This is likely due to the co-design process only happening with one of the educators and not both due to time constraints and work schedules which caused there to not be balanced input from both educators on preferences. Going forward having group meetings rather than one educator is recommended. Additionally, it was pointed out that allowing annotations to be over a period of time, having an editable start and end time, would be a significant and useful enhancement as feedback can be more clearly tailored to an entire movement that a student is attempting. This was an initial feature during early designs but was cut due to time constraints early in development as more important features were prioritized. Due to it being brought up here it is highly encouraged that further development focuses on implementing this feature. Both participants agreed on the usefulness of the feedback feature believing it would be a great asset

for students as they can always rewatch videos and see explanations to improve their mistakes. Similarly, the quiz was perceived as highly useful. The comment mentioning that the effectiveness of the quiz is hard to comment on due to it not being used before for dance also supports the need for additional development on the quiz and for a longer-term study to test for demonstrable effects on a student's dancing based on the use of the quiz. The addition of free text elaboration for the quiz answers is also an interesting idea but would require additional design meetings to decide on an implementation that would work for it.

Overall, the participants perceived the application as helpful and a success.

9 CONCLUSIONS

This report represented the development cycle of a Video Annotation mobile application to supplement in-person social dance classes in South Africa. Based on the results of the evaluations in Section 7 and the analysis conducted in Section 8 it can be seen that the development cycle and goals set for each iteration allowed for the creation of a successful prototype. Additionally, the positive feedback and the perceived usefulness of the developed features supports the need for an application of this nature. Overall, the entire cycle of design, development and testing can be seen as a success and worthwhile to continue pursuing further.

10 FUTURE WORK

Due to this project's focus on analyzing the educational benefits of mobile video annotations rather than creating a complete mobile application, there is plenty of ideas that can be implemented in the future. Many of these were mentioned in Section 8.1.1 such as a custom database for storing the videos and annotations, the ability to upload new videos to the app, the creation of accounts and the sending of videos and possibly their attached feedback between accounts. Additionally, future work could be used to separate the teacher and student user interfaces depending on the account logging in thus removing confusion from the general screen as it currently stands. Should the project continue it would be prudent to develop a version of the application for other operating systems, particularly iOS.

From the feedback acquired in the evaluations features such as a next and previous button within the quiz, a customizable start and end time in the annotations and tutorials upon first use are features that should also be developed to improve the application. Additionally, it would be encouraged to engage in additional co-design meetings with both educators and run a long term study to observe the effects of using the application rather than just the perceived usefulness.

11 ACKNOWLEDGEMENTS

I would like to thank Tracey Cable of Evolution Dance Studio for helping to co-development the Annotation Vocabulary, taking time to meet with me for progress reports and participating in the evaluations. I would also like to express gratitude and thanks to Angus Prince of Evolution Dance Studio for providing the videos used within the application, organizing students for the evaluations and

participating in the evaluations himself. Without their assistance, this project would not have been possible. I would also like to thank the second reader Hussein Suleman for his time and feedback. Finally, I would like to thank my project supervisor Professor Maria Keet for her guidance, support and time throughout this project.

REFERENCES

- [1] John Brooke. 1996. *Usability evaluation in industry*. Chapter SUS-A quick and dirty usability scale, 4–7.
- [2] Po-Sheng Chiu, Hsin-Chin Chen, Yueh-Min Huang, Chia-Ju Liu, Ming-Chi Liu, and Ming-Hsun Shen. 2018. A Video Annotation Learning Approach to Improve the Effects of Video Learning. *Innovations in Education and Teaching International* 55, 4 (2018), 459–469. <https://doi.org/10.1080/14703297.2016.1213653>
- [3] Rosemary E. Cisneros, Kathryn Stamp, Sarah Whatley, and Karen Wood. 2019. WhoLoDanceE: digital tools and the dance learning environment. *Research in Dance Education* (2019), 54–72. <https://doi.org/10.1080/14647893.2019.1566305>
- [4] Bruna Cunha, Olibário Machado Neto, and Maria da Graça Pimentel. 2013. MoViA: a Mobile Video Annotation Tool. In *Proceedings of the 2013 ACM Symposium on Document Engineering*. ACM, 219–222. <https://doi.org/10.1145/2494266.2494267>
- [5] Bruna Cunha, Diogo Pedrosa, Rudinei Goularte, and Maria da Graça Pimentel. 2012. Video Annotation and Navigation on Mobile Devices. In *Proceedings of the 18th Brazilian Symposium on Multimedia and the Web*. ACM, 261–264. <https://doi.org/10.1145/2382636.2382691>
- [6] Augusto dos Santos, Lian Loke, and Roberto Martinez-Maldonado. 2018. Exploring Video Annotation as a Tool to Support Dance Teaching. In *Proceedings of the 30th Australian Conference on Computer-Human Interaction*. ACM, 448–452.
- [7] Katerina El Raheb, Aristotelis Kasomoulis, Akrivi Katifori, Marianna Rezkalla, and Yannis Ioannidis. 2018. A Web-Based System for Annotation of Dance Multimodal Recordings by Dance Practitioners and Experts. In *Proceedings of the 5th International Conference on Movement and Computing*. ACM, 1–8. <https://doi.org/10.1145/3212721.3212722>
- [8] Lu-Ho Hsia and Gwo-Jen Hwang. 2020. From Reflective Thinking to Learning Engagement Awareness: A Reflective Thinking Promoting Approach to Improve Students' Dance Performance, Self-efficacy and Task Load in Flipped Learning. *British Journal of Educational Technology* 51, 6 (2020), 2461–2477. <https://doi.org/10.1111/bjet.12911>
- [9] Wolfgang Hürst, Cees Snoek, Willem-Jan Spoel, and Mate Tomin. 2010. Keep Moving: Revisiting Thumbnails for Mobile Video Retrieval. In *Proceedings of the 18th ACM International Conference on Multimedia*. ACM, 963–966. <https://doi.org/10.1145/1873951.1874124>
- [10] Wolfgang Hürst, Cees Snoek, Willem-Jan Spoel, and Mate Tomin. 2011. Size matters! how thumbnail number, size, and motion influence mobile video retrieval. In *Proceedings of the 17th international conference on Advances in multimedia modeling - Volume Part II*. Springer-Verlag, 230–240. <https://doi.org/10.1145/1873951.1874124>
- [11] Rajkumar Kannan, Frederic Andres, and Christian Guetl. 2010. DanVideo: An MPEG-7 Authoring and Retrieval System for Dance Videos. *Multimedia Tools and Applications* 46, 2 (2010), 545–572. <https://doi.org/10.1007/s11042-009-0388-3>
- [12] J Nielsen and R Molick. 1994a. Enhancing the explanatory power of usability heuristics. In *Proc. ACM CHI'94 Conf*. ACM, 152–158.
- [13] Katerina Raheb, Marina Stergiou, Akrivi Katifori, and Yannis Ioannidis. 2019. Dance Interactive Learning Systems: A Study on Interaction Workflow and Teaching Approaches. *Comput. Surveys* 52, 3 (2019), 1–37. <https://doi.org/10.1145/3323335>
- [14] B. Ramadoss and K. Rajkumar. 2007. Modeling the Dance Video Annotations. In *International Conference on Digital Information Management*. IEEE, 145–150. <https://doi.org/10.1109/ICDIM.2007.369344>
- [15] Cor Suhre, Koos Winnips, Vincent de Boer, Pablo Valdivia, and Hans Beldhuis. 2019. Students' experiences with the use of a social annotation tool to improve learning in flipped classrooms. In *Editorial Universitat Politècnica de València*. Universitat Politècnica de València.
- [16] Sheng-Shiang Tseng. 2021. The Influence of Teacher Annotations on Student Learning Engagement and Video Watching Behaviors. *International Journal of Educational Technology in Higher Education* 18, 1 (2021), 1–17. <https://doi.org/10.1186/s41239-021-00242-5>

12 SUPPLEMENTARY MATERIAL

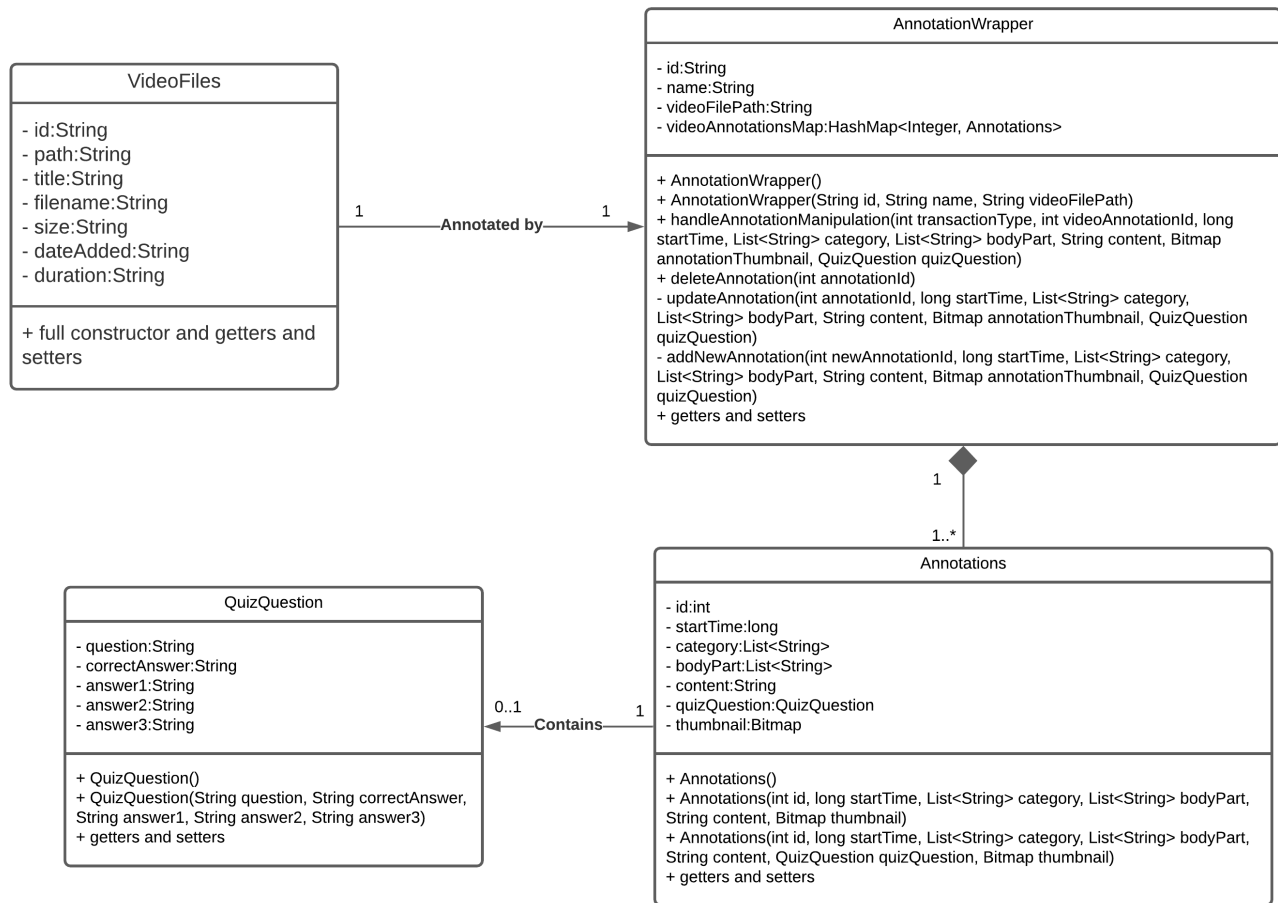


Figure 4: Class Diagram for the Core Classes of the Annotation Tool

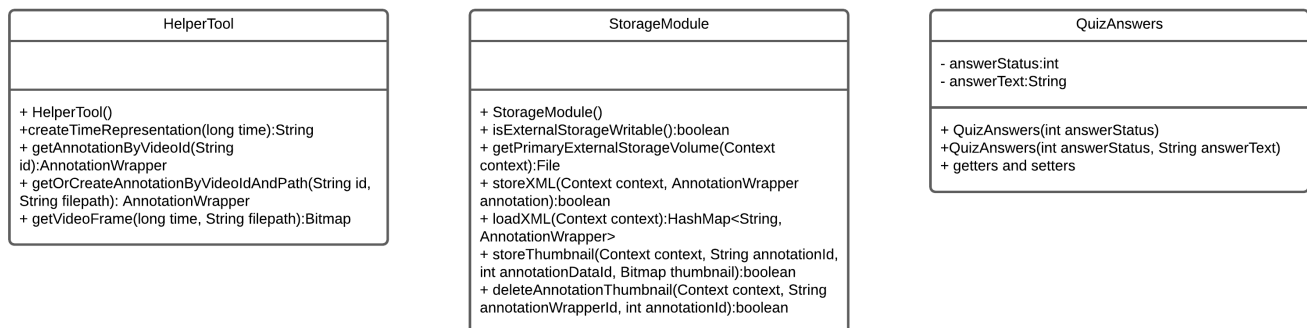


Figure 5: Class Diagram for the Secondary Classes of the Annotation Tool

Class Name(s)	Core Function
MainActivity	<ul style="list-style-type: none"> • Check for and request permission to external storage. • Allow switching between the four feature sets of the application. • Call code to load all videos and annotations. • Maintaining the static variables to share the VideoFiles list and AnnotationWrapper HashMap with other activities and fragments.
PlayerActivity	<ul style="list-style-type: none"> • Setup and play the selected video • Display controls for the video • Handle onclick calls for creating new annotations, saving annotations, using the back button, deleting annotations and using the hint button. • Setup a static hashMap to track answered questions in the quiz. • Display the finished quiz message upon all questions being answered.
FeedbackVideosFragment, QuizVideoFragment, VideoAdapter	<ul style="list-style-type: none"> • All three classes are used to display the list of videos available for selection in each of the four app sections. • FeedbackVideosFragment and QuizVideoFragment inflate the layout that is presented. • VideoAdapter inserts the content into the RecyclerView within the layouts and sets the behaviour for onClick methods.
AnnotationDisplayFragment, AnnotationDisplayAdapter	<ul style="list-style-type: none"> • Both classes are used to display the list of annotations available for selection within each video. • AnnotationDisplayFragment inflates the layout that is presented. • AnnotationDisplayAdapter inserts the content into the RecyclerView within the layouts and sets the behaviour for onClick methods.
AnnotationDetailsFragment, AnnotationDetailsFragmentEditing	<ul style="list-style-type: none"> • AnnotationDetailsFragment inflates the UI displayed when a new feedback annotation is created. • AnnotationDetailsFragmentEditing inflates the UI displayed when a feedback annotation is edited. • Both classes contain the methods used to create, edit, save and delete annotations. They pass the required variables into the methods on the AnnotationWrapper class for editing and creation and then make use of the StorageModule class to save them. For deletion, they make the calls to the StorageModule.
QuizCreationFragment, QuizCreationFragmentEditing	<ul style="list-style-type: none"> • QuizCreationFragment inflates the UI displayed when a new quiz annotation is created. • QuizCreationFragmentEditing inflates the UI displayed when a quiz annotation is edited. • Both classes contain the methods used to create, edit, save and delete annotations. They pass the required variables into the methods on the AnnotationWrapper class for editing and creation and then make use of the StorageModule class to save them. For deletion, they make the calls to the StorageModule.

QuizAnsweringFragment, ViewFeedbackFragment	<ul style="list-style-type: none"> • QuizAnswerFragment and ViewFeedbackFragment inflate the views for the students to interact with the quizzes and feedback respectively. • The QuizAnsweringFragment additionally creates the random hint that will be displayed when the Hint button is clicked. • The QuizAnsweringFragment additionally sets up the random button positions to ensure the correct answer is always in a different position and sets up the onClick functions for correct and incorrect buttons being selected.
MultiSelectionSpinner	<ul style="list-style-type: none"> • The MultiSelectionSpinner is a custom class extending the built-in Android spinner widget. • It was used for the creation of both quiz and feedback annotations to allow the selecting of multiple categories and bodyparts to be associated with a single annotation.

Table 2: Android Studio Class Names and Core Functions

SUS Statements	
1	I think that I would like to use this application frequently
2	I found the application unnecessarily complex
3	I thought the application was easy to use
4	I think that I would need the support of a technical person to be able to use this application
5	I found the various functions in this application made sense and were helpful
6	I thought there was too much inconsistency in this application (it didn't feel like a single unified application)
7	I would imagine that most people would learn to use this application very quickly
8	I found the application very cumbersome to use
9	I felt very confident using the application
10	I needed to learn a lot of things before I could get going with this application

Table 3: System Usability Scale Statements

Survey Statements and Questions	
Applicable to both Groups	
11	I feel that this application will provide a good supplemental experience to in-person classes. (Likert Scale Statment) Motivate your answer.
12	What feature did you like most about the application?
13	What is your overall opinion on the application?
14	Are there any points you'd like to address that did not come up in the questions?
Applicable to Teachers Only	
15	Are there any additional features for annotating videos for feedback and quizzes that would improve the experience for you?
16	Do you feel that these annotated feedback videos would help your students improve their dancing? Please motivate your answer.
17	Do you feel that the annotated quizzes will help your students understand the technique and theory of the dances? Please motivate your answer.
Applicable to Students Only	
18	The presentation of the teacher feedback was easy to understand. (Likert Scale Statement) Explain your answer?
19	Do you feel the quiz feature would help you to learn basic theory and technique before coming to class?

Table 4: Additional Survey Statements and Questions

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
P1 (T)	4	2	4	1	4	5	5	1	5	2
P2 (T)	3	2	4	1	3	2	3	2	3	2
P3 (S)	3	1	5	1	5	1	5	1	4	1
P4 (S)	3	1	4	1	4	1	3	1	5	1
P5 (S)	4	1	4	1	4	3	4	1	3	2
P6 (S)	4	1	5	1	5	1	5	1	4	1

Table 5: System Usability Scale Results

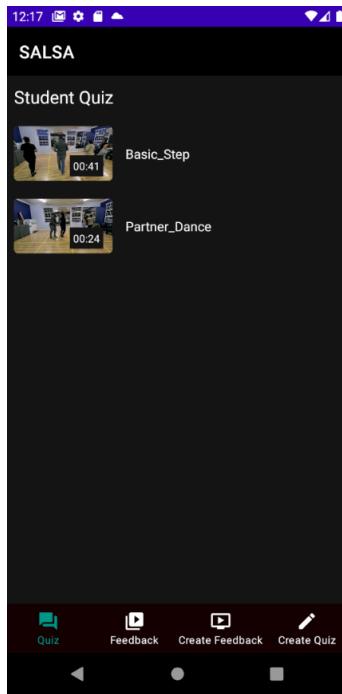


Figure 6: Main Screen with 4 Tabs for the different sections of the App

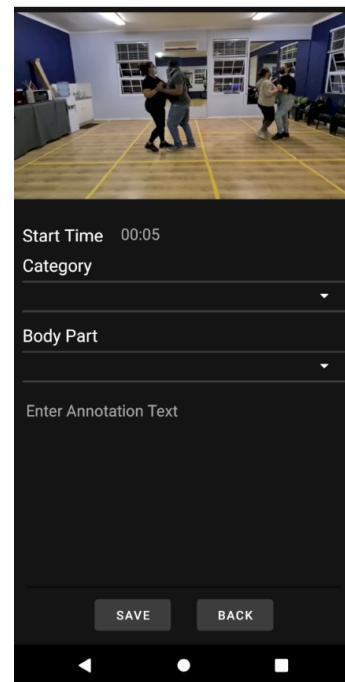


Figure 7: Blank Form for Creating Feedback Annotation

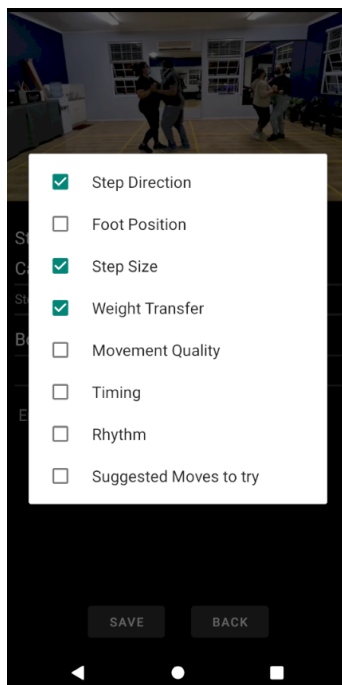


Figure 8: Category Selector for Annotation Creation Displaying Multi-Select Capability

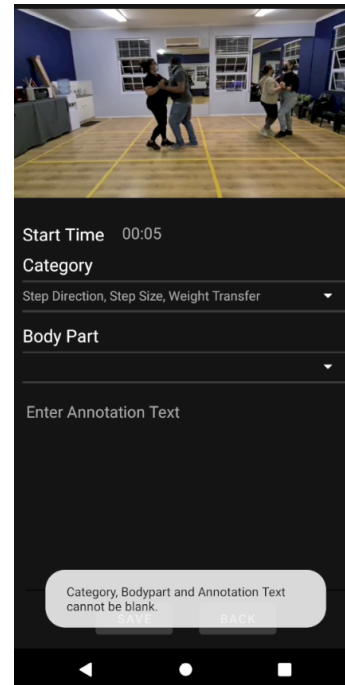


Figure 9: Annotation Creation Failure due to missing information

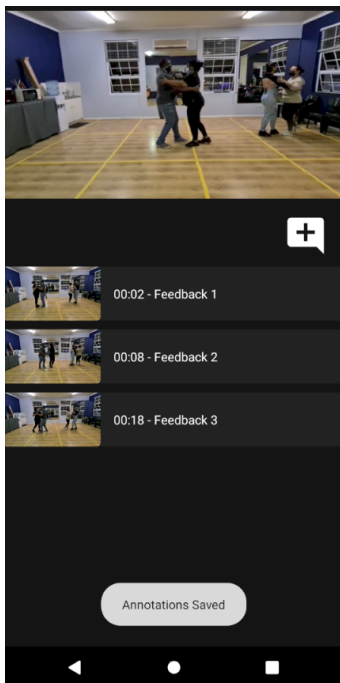


Figure 10: New Annotation Saved Response and Created Annotations List

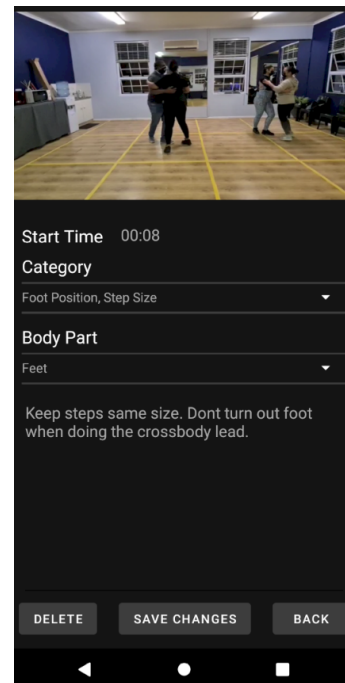


Figure 11: User Interface appearance for Editing Feedback Annotations

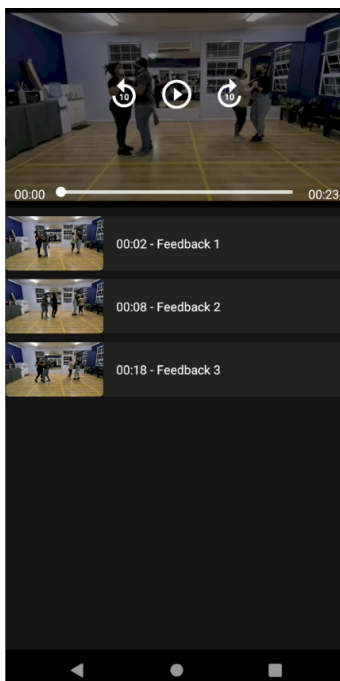


Figure 12: Feedback List as it Appears to Students

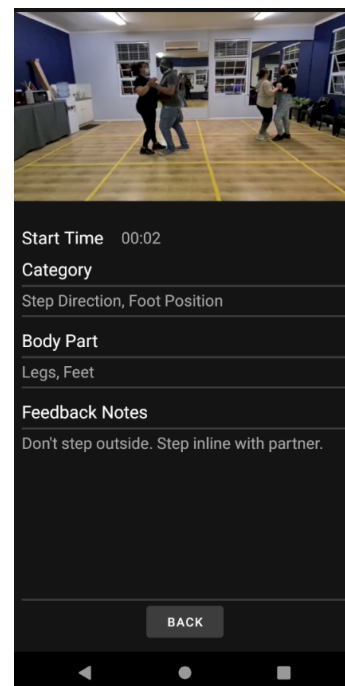


Figure 13: Feedback Annotations as they appear to Students

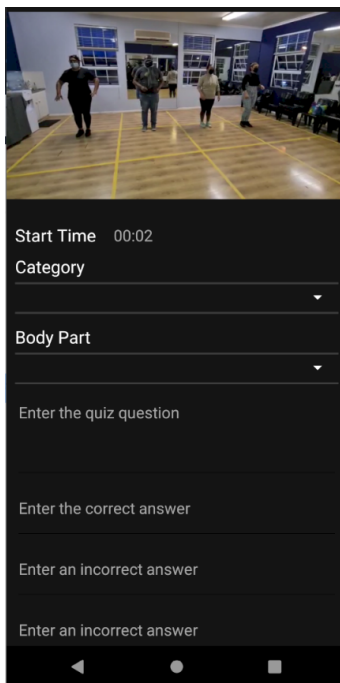


Figure 14: Quiz Creation Screen

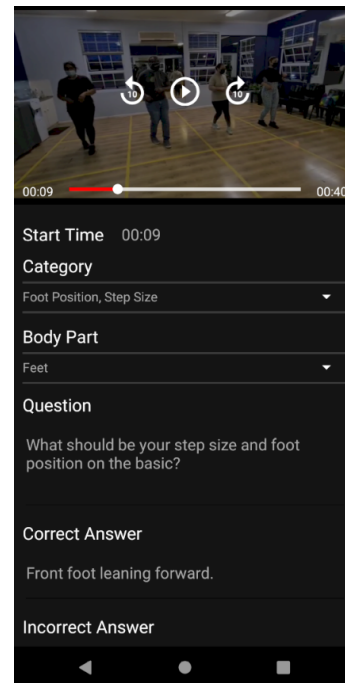


Figure 15: Quiz Editing Screen

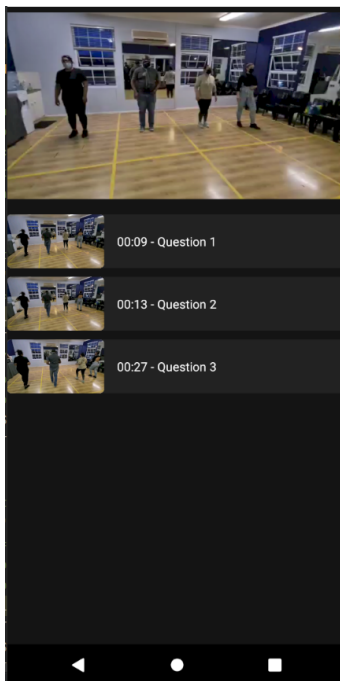


Figure 16: Quiz Question List as Displayed to Students

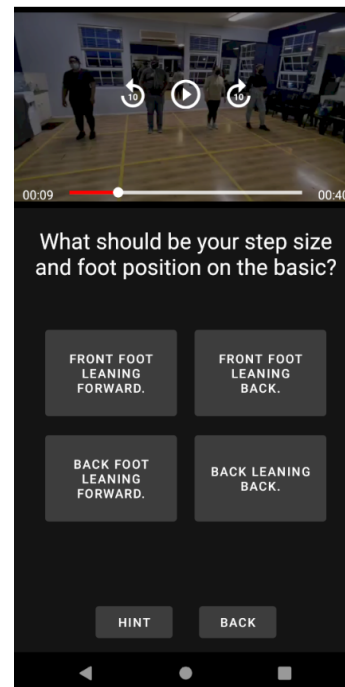


Figure 17: Quiz Answer Screen Before Selecting an Option

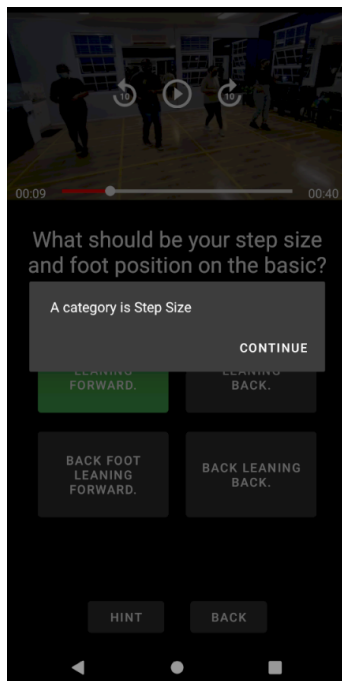


Figure 18: Quiz Answer Screen Hint Function

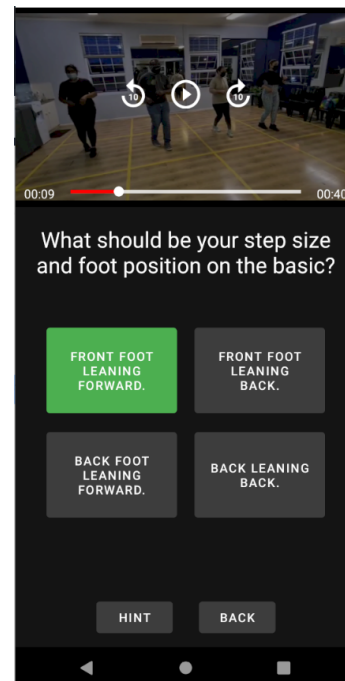


Figure 19: Quiz Answer Screen with Correct Answer

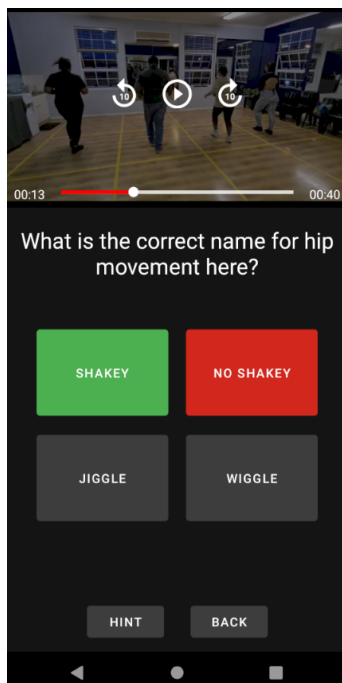


Figure 20: Quiz Answer Screen with Incorrect Answer

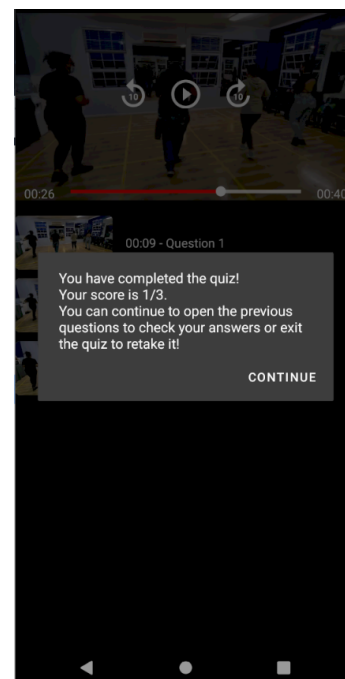


Figure 21: Quiz Complete Popup Display