

# **A Study of the Interactivity of Intelligent Piano Education Applications**

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A research paper submitted to the University of Dublin,  
in partial fulfillment of the degree of  
Master of Science Interactive Digital Media.

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## Summary

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This thesis aims to support the body of designing knowledge regarding piano education applications and explore the aspects that make apps effective as learning tools. This paper intends to adopt a framework to identify user interaction features contained in a small selection of apps as well as improvements. To analyze this interaction, the chosen framework is an educational games framework, based on Alevan et al. consisting of 3 components: Bloom's taxonomy for precisely specifying educational objectives; MDA game analysis framework for relating three interrelated elements: mechanics(M), dynamics(D) and aesthetics(A); research-based instructional design principles for considering the consistent between learning ways provided by games and empirical instruction and guidelines. The reason to choose an educational game framework is that piano teaching apps have many similarities to games in designing. The specific contents and characteristics of this framework, as well as the analysis process, will be discussed in depth in chapter2.

## Chapter 1 - Introduction/Background

### 1.1. The benefits of music and piano

Music has become an essential part of people's daily life with powerful effects to alleviate the anxiety or boredom of tedious life, to promote relaxation and to optimize subjective well-being (Susan Hallam 2013). Among adult music students, the most popular instrument of choice is piano (Jutras, P. J. 2006). Learning to play the piano will bring learners many benefits such as reducing depression to adjust mood states, improving executive function and promoting intellectual development (S. Seinfeld 2013) for adults; gaining pleasure and enjoyment as well as improving the ability of concentration and self-discipline for children.

### 1.2. The difficulty of accepting piano education traditionally

Learning to play the piano is quite challenging as it requires years of time and effort to practice and financial support for reaching a moderate mastery.

A substantial portion of piano students quit lessons before obtaining piano skills. Some evaluations estimated that the drop-out rate for beginners' course reaches up to 95% (Pingel, J 2011). Several reasons caused this problem: (1) A lack of intrinsic motivation derived from their limited skills to achieve higher expectations to play well (K. King 2016) such as fast sight-reading, rhythm, accuracy, and flexibility of finger, memorizing sheet music and understanding of musical works. (2) The limitation of receiving instant and interactive directives or feedback from teachers. As the tutorial time is only a few hours per week, it is difficult for instructors to provide students with intensive and deep evaluation while imparting techniques. This problem leads students to choose self-study when they are at home.

Another huge group who plan to learn piano do not turn their ideas into reality because of several obstacles from high budget and tight daily schedule. As piano learning is a continuous process, it requires learners to take an investment of time and money. A grand investment in piano tutoring is a fundamental reason. Figure 1.1 demonstrates that the average cost for one on one piano lessons is 30 GBP per hour. Generally, hiring a private piano instructor to guide the student to play piano, they will likely spend between 24GBP and 36GBP on each lesson so learners may feel hindered by the daunting cost of piano lessons. Besides, for most busy adults, it is difficult to commit traditional weekly lessons or daily practicing lessons. These factors lead to the situation that many people owing a dream to play the piano have to give up their unrealistic ideas.

UK National Minimum Cost	£24
UK National Maximum Cost	£36
UK National Average Cost	£30
Average Range	£24 -£30

Figure 1.1. Piano Lessons Costs in UK, 2019

### 1.3. The intelligent tutoring system in piano education

In the earliest piano teaching classes, private piano teaching is the most traditional and popular teaching mode in the piano education field with two main teaching tools, piano and sheet music. The content of the class was based on teachers' explaining music theory and performance skills and guiding the students on how to play. Normally, teachers will formulate corresponding teaching plans and give improvement advice according to students' learning performance. The instructing form was relatively simple.

APP	Price
Playground sessions	\$17.99/month \$119.88/year \$289.99 one-off payment for lifetime membership
Flowkey	\$19/month \$120/year
Simply piano	\$59.99/3months \$89.99/6months \$119.99/year
Piano marvel	\$15.99/month \$110.99/year
Skoove	\$19.99/month \$39.99/3 months \$119.99/year

Figure 1.2. Piano Teaching subscription fees 2020

Recent years have witnessed an explosion in the use of smartphones and tablets. With that, online tutoring apps designed for guiding how to master a musical instrument are becoming quite common. This kind of intelligent piano teaching apps like Simply piano, Flowkey, Piano marvel, Yousician, Playground sessions are available in the App store. In terms of current development in the online piano teaching market, the integration of piano education and intelligence has achieved some accomplishments.

The difficulty of learning to play piano has been reduced than ever before with a series of development of humanized and intelligent piano teaching apps considering the cost of time and money. Learning with online pre-prepared piano lessons helps learners achieve flexible studying time which means they can attend classes at a time that suits their schedule and take learning at their own pace. Affordable app subscription fee and good compatibility among keyboard, digital piano, and traditional piano have greatly reduced the financial cost of learning to play the piano.

### 1.5. Selection criteria

Apps were selected as research examples according to the following criteria. To be an appropriate research objective for review, each app must:

1. Provide the step-by-step piano lessons designed for adults based on sheet music, reading notes
2. have intelligence and interaction components
3. be available on app stores either in Google or Apple
4. specialize in providing piano tutorials instead of multi-instruments.
5. require little to no previous piano knowledge or skills

Special features, similarities among them will be analyzed in the following chapters. The selected apps include Simply Piano, Piano Marvel and Flowkey. The first app, Simply Piano, provides a fast and fun way to learn piano, from beginner to pro. Learners just need to follow the well-designed and organized path. The overall learning process is like playing a game when they master essential skills and put it into practice correctly and then they can proceed to the next level. The second app, Piano marvel, the learning mode is divided into two hand-in-hand sections-method and technique, with skills that are taught in the method section and reinforced in the technique section. The third app, Flowkey is an app based on playing your favorite songs from beginner to pro with the support of video courses to know about notes, chords, and other proper techniques.

## Chapter 2 - Analyzing frameworks and methodology

The analysis of piano education apps needs a theoretical approach to identify and analyze the significant design standards during the creation of intelligent piano tutoring systems (Alven, et al., 2010). In this work, the author will use a framework from the design and analysis theory of educational games, which is built on learning sciences. The reason to choose an educational game framework is that piano teaching apps share some similar features with educational games to some extent. A game requires “a rule-based system with an unpredictable and quantifiable outcome, where players exert effort to achieve the goal” (Adams and Formans 2012). Piano education apps require likewise participants to input and act in accordance with rules for the desired goal. Therefore, this educational game framework involves the part of piano educational designing of the app as well as the part of user interaction.

The framework proposed by researchers from Carnegie Mellon University includes three components: learning objectives, MDA and Instructional Design Principles for analyzing or designing educational games.

To specify the app’s educational objectives, Bloom’s Revised Taxonomy would be adopted as a clear identification of learning objectives. This theory can “ensure that the app meets an intended and coherent set of educational goals and achieves the degree of truly educationally effective” (Alven, et al., 2010). Additionally, MDA structure is chosen to analyze the main components of a piano teaching app involving mechanics, dynamics, and aesthetics. In spite of these, utilizing the collection of research-based instructional design principles provides a thinking way to evaluate “how the app supports learning, whether it does so in ways consistent with learning sciences findings and recommendations and what principles does the app violate or ignore” (Alven, et al., 2010, p. 73).

The first three sections of this chapter introduce this frame in depth according to three components. The fourth section explains how to take the theoretical approach to practical analysis.

### 2.1 Learning objectives

In order to specify what educational goals the apps should achieve, three questions need to be considered:

1. (Prior knowledge) What knowledge or skills do students/players need to have before starting the game?
2. (Learning and retention) What knowledge or skills can students/players reasonably be expected to learn from the game?
3. (Potential transfer) What knowledge and skills might they learn that go

beyond what they actually encountered in the game? (Aleven 2010)

## 2.2 MDA Structure

The second component, MDA structure consists of mechanics, dynamics and aesthetics which are three intrinsically connected levels of game analyzing.

The mechanical principles of a game are "the precisely specified rules"(Adams 2012) which are building blocks for motivating behaviors. These include the materials, gameplay, explicit levels, challenges, goals, basic moves, and control options available to the players (Aleven 2010). This paper is going to identify the types of mechanics that were created in Intelligent Piano Education Applications and how those mechanics promote the interaction between users and piano teaching apps.

The Dynamics of the game define "the patterns that form when combining the game's mechanics with player input during gameplay" (Aleven 2010). Well-designed dynamics can make piano teaching activity enjoyable and keep learners engaged as long as possible. Game mechanics are precisely customized by game dynamics for special needs and interests or motivations of participants. This paper will look at how dynamics help mechanics to engage users.

The aesthetics demonstrate "different emotional responses evoked in players, comprising 8 items : Sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission" (Aleven 2010). This paper will explore the influence of visuals and sound at the subjective experience of players.

## 2.3 Instructional design principles

Concerning learning sciences and piano teaching apps, the third component, instructional design principles adopt some collections of research-based principles from summaries of educational researchers, mainly the Life-Long Learning principles and game-based learning principles.

The Life-Long Learning principles are summarized and proposed by Arthur Graesser from the University of Memphis. It includes 25 principles of learning which provide a checklist of effective learning strategies grounded in science. James Gee from the University of Wisconsin- Madison developed and reviewed 36 learning principles found in games. "The main function of these principles is that they "provide a way to think and talk about how a game supports learning, and whether it does so in ways consistent with learning sciences findings and recommendations." (Aleven 2010) Another function is that it is an effective way to find "principles that a game might violate or ignore" and to generate

redesign ideas. (Alevén 2010) Adherence to these principles can help games-based learning attract learners' attention, stimulate learners' interests and promote learning more effectively.

## 2.4 Analysis Process

The steps followed for the analysis are:

1. Summary and identification of the main learning goals of piano education applications will answer three questions mentioned before such as prior knowledge and skills that users should have, expected learning achievements.
2. Next, we tend to analyze the three interrelated levels of the game, which is helpful to see how the teaching is implemented effectively.
3. The third step is to identify instructional principles that applied in the piano teaching syllabus. Considering whether instructional design meets the requirements of professional education theories can ensure the rationality and practicality of apps.
4. After finishing the analysis of three components, I will use each of them as a focus about redesigning ideas to provide some modifying suggestions.

## Chapter 3 – Simply piano

### 3.1 Introduction to the app

Simply piano is an app that was released in the year of 2015, developed by JoyTunes whose mission is to help people reduce barriers to enter the music learning world and achieve their musical dreams by using cutting-edge technology. It is highly popular and has been recognized by many awards such as Apple's Editor's Choice Award, Parents' Choice Award, and Best App from Google Play.

Simply piano is available on mobile phones and tablets and this app is compatible with any acoustic piano, digital piano or keyboard, including a MIDI keyboard. All users need to do is to download it to your devices and follow the stream of courses. Learners' devices will use the function of note recognition to judge users' input and provide instant feedback to improve learners' the accuracy of playing.

This is a self-teaching app which means users don't need to hire piano teachers. The game-like format is the most obvious feature of teaching mode, supported by videos and interactive, progress measuring lessons. This is designed for piano enthusiasts who want to accept piano courses step by step from basics without requirements of previous knowledge and skills. It is advertised as a "fast and fun way to learn piano."

### 3.2. Learning objectives

Following the analytical framework, the learning objectives of Simply piano can be analyzed as follows. First, as for the prior knowledge (question1) that learners need to have, this is a novice-friendly app which is designed for users who don't have prior theoretical or practical foundation at the piano. In other words, anyone with enthusiasm in piano can freely use the app to achieve the first step of their piano dream. This feature is reflected in the curriculum.

- Before the courses split into the Soloist and Chords tracks, two courses are designed to help novice build an essential and quick foundation, whatever their previous piano experience is. The courses, "Piano Basics" and "Essentials I" will teach students finger numbers, basic rhythm, a couple of easy chords and few notes in the right hand. At the same time, in order to keep learning fun, course directors specially created simplified versions of popular songs such as "Perfect" by Ed Sheeran and "Jingle Bells". The threshold for entering the piano field is greatly reduced.



Figure 3.1. The interface of Piano Basics Courses

Question 2 requires the developer to consider learning and retention. By following the series of modules, learners are more likely to acquire familiarity with, fluency with, deep understanding of reading sheet music, specific notes, intervals, chords, rhythms, playing their favorite songs and hand coordination skills. Examples of course arrangement at which the Simply Piano students/users will likely improve are:

- Simply piano currently provides 27 different courses divided into two streams: soloist and chords. **The path of the soloist** is designed to mainly teach learners how to play favorite songs or piano pieces that include sheet music, sight-reading, coordination, and technique. It does this with an emphasis on reading music, playing melodies, expanding learners' note range and polishing up technique. The key techniques and knowledge of lessons are merged within the context of a song, so learners may feel that they are playing something enjoyable instead of tedious practicing.

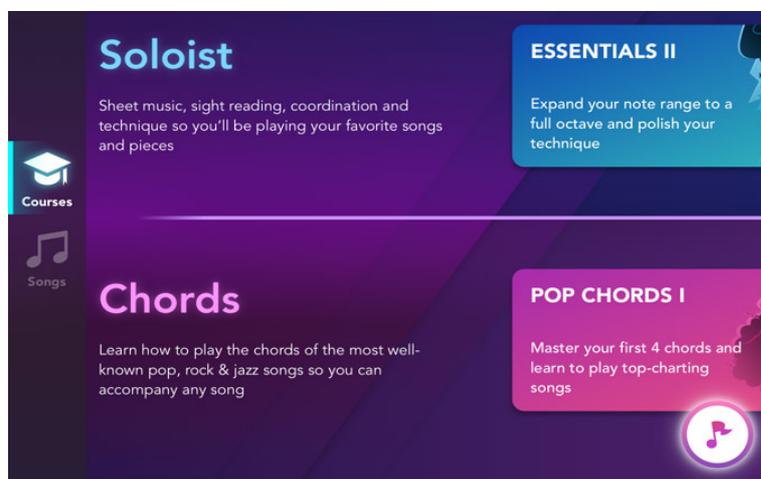


Figure 3.2. The interface of the paths of Soloist and Chords

Essentials II and III are arranged to expand note scales to 2 octaves, teaching C and F positions, accidentals, and guiding users playing the one-octave C major scale inside of a song.

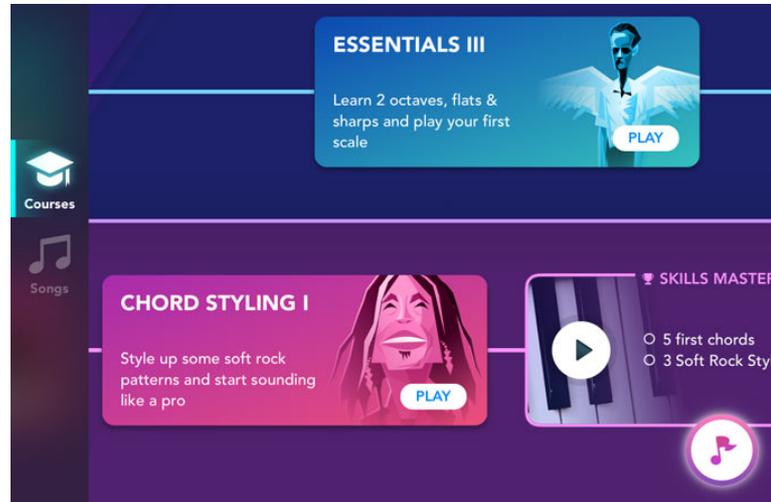


Figure 3.3. The interface of Essentials and Chord styling Courses

Two "Classical" lessons are also arranged. The first one starts with music history and different styles in each period before moving to play simplified versions of pieces from Classical and Romantic periods. The second one "Classical-Für Elise" comes from an excerpt of Beethoven's "Classical-Für Elise".

Accepting Intermediate I, II, III, and IV lessons, students may receive more rhythmically fun with syncopation and ties. They will also learn new scales D and G major and the change of finger positions learned in the essentials courses such as shifting positions and playing higher notes.

Two "Taste of Bach" courses introduce some well-known works of Bach who is the Baroque genius. Students can appreciate and engage in the music style of the Baroque era.

Pre-advanced courses are developing. Students have the chance to enhance skills with key signatures, new positions, and advanced rhythmic skills.

- Another track is Chords which focus on learning how to accompany songs of all genres such as pop, rock and jazz songs, the fundamentals of playing chords and different styles of accomplishments.

"**Pop Chords I**" introduces 4 chords including C major, D major, G major, and E minor in the context of songs like "Knockin' on Heaven's Door" by the Guns 'N Roses and the concept of bassline. "**Pop Chords II and III**" expand chords to F major, D minor, E major, A major, and B minor. Students master these chords by accepting some relevant practice and getting to play a short song that includes these new chords.

"**Chord Styling I, II, and III**" focuses on showing students how to perform different styles, including soft rock, ballad, and classic rock while using the same chords. In the learning process, they are encouraged to put their own feeling and twist on famous songs with chord patterns and techniques after accepting "**Blues Chords I**" "**Jazz Chords I and II**" "**Slash chords**" courses.

Finally, respect to question3, potential transfer, the skills or knowledge may speculate that this app helps students/users master improvisation. This technique is related to a deep understanding of notes, rhythms, chords that the app supports. Strictly speaking, the app does not require skills of improvisation, nor does it reward students/users for mastering it. Nonetheless, a bright student/user may learn this skill by following the course. For example, they may be equipped with certain piano performance skills, chords knowledge, and music theories. However, Simply Piano provides no direct support for learning this skill. Therefore, this kind of problem can be categorized as transfer, "meaning that they go beyond what is practiced in the game" (Aleven 2010). Since predicting transfer is difficult in general, it is hard to say whether and how much students/users will learn about improvisation.

With a detailed understanding of what an app is designed to accomplish, the designer of an educational app tends to create an effective educational tutoring system in a better perspective or to produce creative redesign ideas.

### 3.3. Mechanics, dynamics and aesthetics

The important aspect of MDA framework is to analyze how the game's mechanics, dynamics and aesthetics support piano learning contents or goals.

#### **Mechanics**

The core mechanism adopted by Simply Piano is progression. As piano performance involves an abundance of knowledge and techniques that students must acquire, exposing them to all these at the same time may lead to an overwhelming experience and speed up the loss of interests of learners. The mechanics of progression help designers to dictate "what contents players

will learn first, what resources they will start with, and what tasks they must perform to proceed." (Adams 2012) The clever way that designers took to tackle this problem is to break it down in easy-to-handle chunks. Developers arrange the learning content in scientific sequence according to reasonable piano learning principles and then they are organized by different levels from basics to intermediate and pre-advanced. Individual levels especially have clear defined missions that set goals the learners are going to achieve and structure the tasks they have to complete so as to enter the next level. Learners just need to follow the course stream and don't need to worry about where to start. The function of Levels is often regarded as a reward system to encourage players to continue the game. (Bohyun) The mechanisms of Simply Piano keep this app entertaining and users very engaged in the learning process.

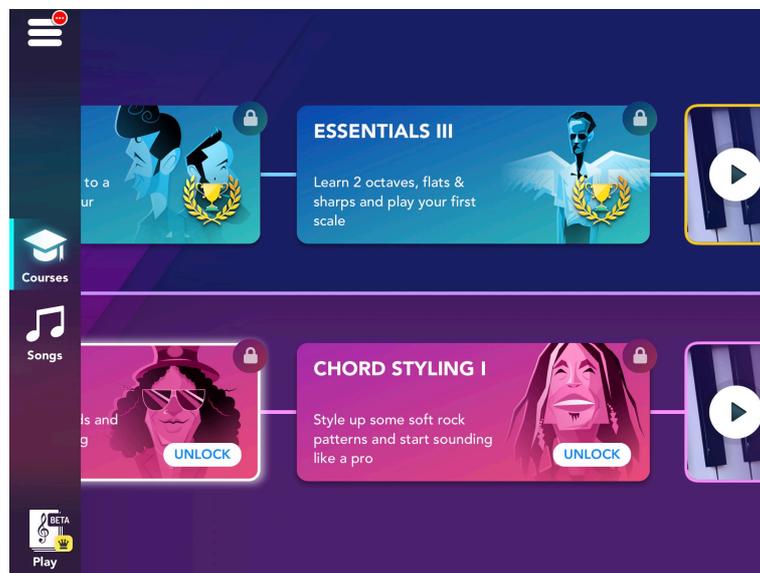


Figure 3.4. The interface of Piano Courses

## Dynamics

Dynamics in the MDA model must be designed carefully to support learning contents and aesthetic experience. Different-paced dynamics are adopted to achieve diverse educational objectives that the app aims to support. For helping students execute a skill fluently, a fast-paced dynamic may be more effective. Simply piano gives students limited chances and time to recognize notes which means students have to enhance the familiarity at memorizing notes positions. While sometimes Simply Piano generates a deliberate, slow-paced dynamic. when students get into the scrolling mode (learning mode) there are different options here. Students can use the ear to actually just listen to it first to enhance the ability to identify notes quickly and to choose practice mode to play partly. In addition, if students missed notes or input incorrectly over 2 times, the practice mode will be activated and students can adjust the tempo by themselves.



Figure 3.5. The practice levels of a song

## Aesthetics

Each game pursues multiple aesthetic goals. Under the category of aesthetics, the challenge is most closely related to Simply Piano. This main focus of the piano teaching app and a significant impact on shaping a user/learner's aesthetic experience is the challenge of accepting and playing each note accurately. It is obvious to see that the learning contents enhance users' feeling of challenge. The fast recognition of notes and chords, sight-reading skills and hand-coordination skills are required to finish course tests at each level, which are not easy for users/learners with the increasing course contents and the difficulty of learning. A lot of special game mechanics further add the challenge experience. For example, the way that app gives users instant feedback is that if they play right, the black note turns blue; if they miss it, it turns red and if learners miss too many notes, it has students to play it again. If the user misses too many notes twice, it puts students into practice mode automatically and slows down the tempo for them. A secondary aesthetic element associated with Simply piano is sensation through sound, visuals that students encounter in the app for motivational purposes. Simply piano tends to create an interesting teaching environment combining with game-like video tutorials, audio hints and sheet music. These means are beneficial to reduce the tedium in learning piano, relieve the study pressure of students and create a relaxing and enjoyable learning experience. Such teaching activity can also reduce the drop-off rate and encourage students to keep learning.

### 3.4. Instructional design principles

Simply Piano implements several research-based instructional principles from collections of the Life-Long learning principles and Jim Gee's 36 principles of game-based learning. Obviously, this app provides ample tests for the practice

of targeted piano skills. After listening to the course of new notes, there is a series of well-arranged notes for learners to catch, each requiring application of new-learned notes and notes that they learned before. Learners can focus on it and it will have them repeat playing over and over so that they get used to playing it and develop some muscle memory. In that case, learners can become familiar with the keyboard, strengthen the coordination between brain and hand as well as increasing the speed of the brain's response. It's just a very engaging technique they use for mastering new notes. Simply piano quite comprehensively covers the enhancement of recognizing notes which is helpful to build a solid foundation of sight-reading. Thus, the game implements Gee#12: "encouraging learners to get lots of practice." A similar idea is expressed in LLL#4: "Testing Effect- The benefit of taking frequent tests is to keep students constantly engaged in the material and enhance their memory."

Further, this app designs the function of instant feedback and guidance. It provides real-time feedback on the success of playing notes accurately or on the failure of missing notes. Thus, the app implements LLL#12: "Feedback effects: Students benefit from feedback on their performance in a learning task ". This provision of guidance by the system when students do not know which notes they should play also reflects Gee#27 "Explicit Information On-Demand Just-In-Time Principle: students should be given explicit instructions both on-demand and just-in-time when students need it."

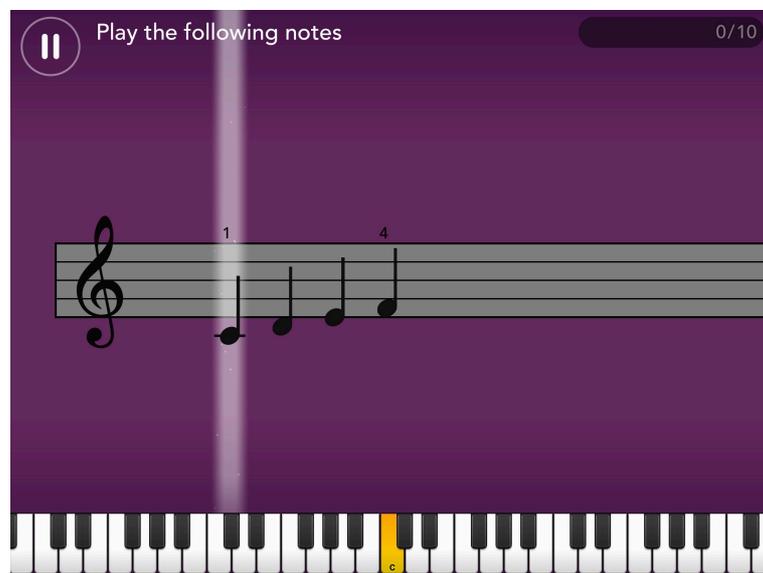


Figure 3.6. System providing guidance

The songs section of Simply piano collected the songs involved in the course and extra challenging songs related to what they have learned which are supplementary exercises for learners to practice. A variety of songs is organized according to the corresponding courses like Essentials I, II, III or Intermediate I, II, III which ensure that students can find songs that fit their

performance ability quickly. Thus, the app reflects LLL#11: "Multiple Examples- An understanding of an abstract concept improves with multiple and varied examples." This can also provide learners an interesting and entertaining learning experience.

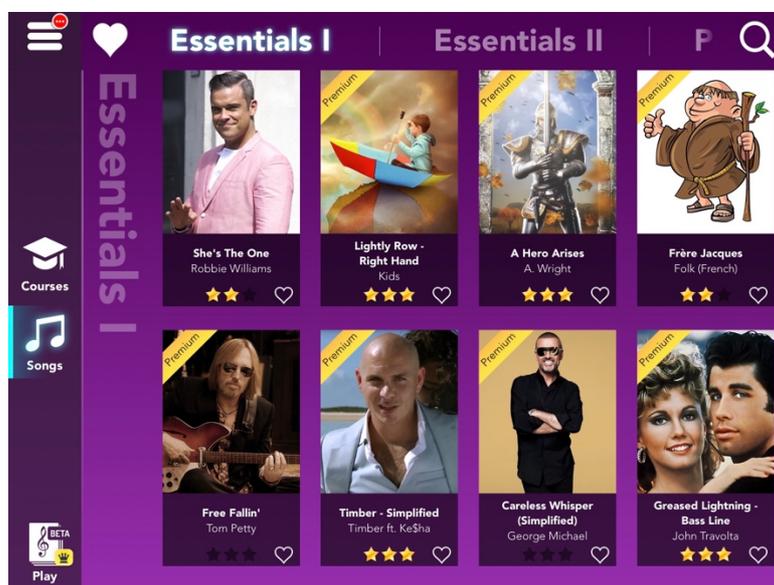


Figure 3.7. The songs section

In addition to supporting enough materials and examples to learners in gaining fluency with reading sheet music, Simply piano tends to keep other resources consistent with courses. The songs library has a good selection corresponding to each level of courses and the playlist collects different kinds of songs from popular to classical which also have different versions from simple, intermediate and advanced. Concerning the design of course contents, developers try to make the course branches as simple as possible up to two branches. These courses are connected with a line to form a stream that learners just need to follow without hesitation to know where to begin. Learners can feel free to stick one path exclusively or mix things up as songs sections have clear partitions for courses. Thus, Simply piano instantiates LLL#9: "coherent effect-The learner needs to get a coherent, well-connected representation of the main ideas to be learned." This principle recommends that "it is important to design coherent learning materials and to remove distracting irrelevant material."

Finally, the fact that reading sheet music in the app gradually become more challenging as the learners advance through higher levels and songs collection contains a variety of music with different difficulty is the practice of LLL#21: "Goldilocks Principle-Assignments should not be too hard or too easy but at the right level of difficulty for the student's level of skill or prior knowledge." It also reveals a similar idea from Gee#14 "Regime Of Competence Principle – learners should have enough knowledge and skills to operate within or at the

edge of resources. Although learners may feel these things are challenging but not undoable."

### 3.5. Combining components to (re)design ideas

- Learning objectives focus

One useful approach to produce design ideas is to focus on educational objectives. Learning improvisation is not strongly supported in Simply piano, which is why we consider this technique as a form of transfer.

- MDA focus

To design a game, MDA can be taken into consideration. It would be interesting to think about how to enhance the challenging aesthetic, discussed above, the different themes of competitions can be launched each week to encourage students to compete with each other and the ranking can be provided to users. Besides, study record function or reports function can be developed for users to track their practice minutes and learning progression which is beneficial to help them to implement and regulate their learning plan.

- Instructional principles focus

A final perspective to generate redesign ideas is to consider introducing new instructional principles into the app. A principle that seems relevant to Simply Piano is LLL#3 "Dual code and Multimedia Effects." which recommends that in the process of delivering new knowledge, students should be given more videos to show accurate fingering by a professional pianist. This would be easier for beginners to imitate and form correct fingering habits. It would be better if users have the option to turn it on or turn it off which avoids that the amount of information would be overwhelming to learners and split their attention.

Further, it would be essential to consider how the Gee#27 "Explicit Information On-Demand and Just-in-Time principle", discussed above, could be supported more strongly, for example by adding a declarative instruction book which summarizes relevant concepts e.g. explanations. Providing printable PDFs of teaching notes can help students ingrain the knowledge.

## Chapter 4 – Piano Marvel

### 4.1. Introduction to the app

Piano Marvel is another strong online piano teaching and assessment software that can be used with or without a private piano teacher. It was born in 2009 and designed by piano teachers. Currently, it is adopted by many piano teachers, music schools and universities such as Baylor University, TAMU, BYU and piano enthusiasts around the world.

With hundreds of powerful features such as ear-training, sight-reading tests, theory, upload music, a large song library, SASR, note hinting, Piano Marvel is quite comprehensive and it claims to be the fastest way to learn piano- four times faster than traditional methods.

People can use Piano Marvel on PC, MAC or iPad to accept bite-sized lessons while tracking their playing accuracy and learning progress with the function of immediate feedback so that students know exactly how to improve their performance.

### 4.2. Learning objectives

According to the analytical framework, the learning objectives of Piano Marvel can be analyzed as follows. This app claims that it is designed for every age and ability level so it assumes that students without prior piano knowledge are also encouraged to use this app. Concerning the prior knowledge that learners need to acquire (Question1), Piano Marvel does not provide a quick conversion in the intro piano, which means learners who don't have previous foundation may find it is difficult to learn.

Question 2 provides the perspective of considering learning and retention. By following this tutoring system, learners are going to acquire familiarity with, fluency with, deep understanding of rhythm and notation, scales, arpeggios, sight-reading, specific technical skills such as hand independence, syncopation, chords, scales, arpeggios, etc. and musical topics such as Sonata form, Rubato, Trills, and Voicing.

In the interface of the dashboard, it is obvious to see that two tabs are labeled "Method" and "Technique" where students want to go to build and strengthen your basic skills of piano play including scales, arpeggios, sight-reading, ear-training, harmonization, and cadences. Each of the tabs contains six levels and each level is divided into 6 sub-levels from A to E while each sub-level is further broken up into 20 lessons. "Method" and "Technique" are designed to go hand

in hand, with skills that are taught in the Method section reinforced in the Technique section.

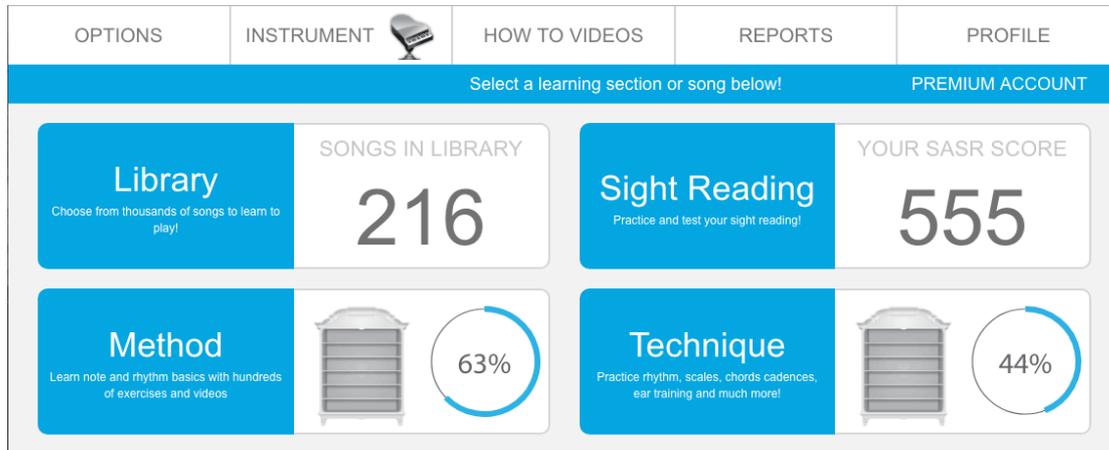


Figure 4.1. The Interface of Dashboard

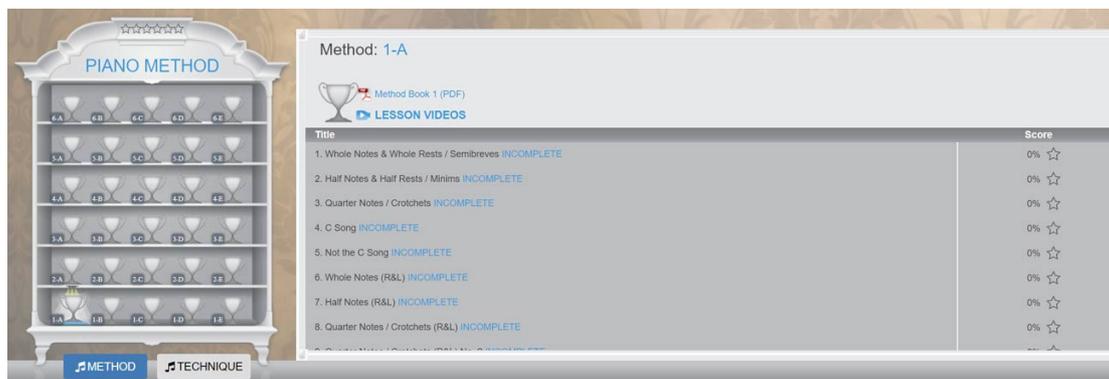


Figure 4.2. The Interface of Method section

Examples of course arrangement at which the Piano Marvel students/users will likely improve are:

- **The Method section** is the place where students do most of the learning and where students will spend a large portion of their practice time.

**Level One** - Covers intro to the keyboard, finger numbers, and posture. The exercises introduce basic rhythm, a few notes, 4/4 time, 6/8 time, and musical terms and symbols like staccato/legato, dynamics, and repeat signs.

**Level Two** - In this level, students will learn new hand positions, steps/skips, pickup notes, accidentals, syncopation, inner ledger lines, and 2/2 and  $\frac{3}{4}$  time and their conducting patterns.

**Level Three** - This is the intro to scales, teaching students the C, G, and F major scales, and the g and f harmonic minor scales. This level also teaches whole/half steps, intervals, chords I, IV, and V7, major/minor, the sostenuto (sustain) pedal, relative majors and minors, key signatures, 12 bar blues, key changes, and crescendo/decrescendo.

**Level Four** - Covers triads and inversions, musical phrasing, pedaling technique, more musical terms, transposition, and the circle of fifths. New scales and triads taught are D, A, Bb, Eb, and Ab major.

**Level Five** - This level is all about reading more advanced sheet music, including things like reading two hands on the one staff, finger substitution, crossing hands, and reading two of the same stave. It also covers Alberti bass, arpeggios, dotted eighth notes, and swing. New keys are a, e, d, and g minor, and F# major.

**Level Six** - This is an intro to the Baroque, Classical, and Romantic eras. It also covers the minimalist composition technique, ornaments, and the f minor scale and triads.

- **The technique lessons** are the rudiments or the ABCs of playing the piano. The purpose of this section is to reinforce what students learn in the method section like scales, chords, rhythm and reading ability by passing off flashcards and ear training exercises in the technique section, which can help improve students' musicality overall as a musician. The instruction book and lessons generally follow along with the contents in the Method section and complement more practice related to the concepts that they learned in the Method section. Their objective is to start working through exercises so as to fill up their trophy case. **Flashcards** are a great way to perfect what students previously learned. They are usually located at the end of the trophy and used as a review tool for the contents that students learned in each trophy such as Notes, intervals, and chords. These knowledge points will constantly pop up on screen and students must give quick responses and play them within the limited given time. **The ear training exercises** are designed to train students' abilities to listen to a note, interval, or chord and know what it is. The exact exercises may work in different ways including singing in solfege, naming intervals and chords, and playing melodies after listening to them.

Finally, respect to question3, potential transfer, music theory and music history and literature involved in this app speculate that it helps users shape the advanced music literacy of students. Music literacy is related to mastering the knowledge of harmony, melody, music appreciation as well as pitch, rhythm, timbre, and strength, etc. Strictly speaking, the app does not provide relevant

learning materials, nor does it reward students/users for mastering these. If app developers pay more attention to teaching music theories, it helps students to better appreciate, analyze, understand and express the connotation of music, and broaden their horizon of music. Their sense of music is cultivated and the ability to appreciate music is also improved. For example, knowing the laws of harmony language can make harmony play more logical, persuasive, and easy to remember, which is conducive to improving the ability of music expression, thereby improving the performance skills. However, Piano Marvel provides no direct support for learning this skill.

#### 4.3 Mechanics, dynamics and aesthetics

The reason to use MDA as an analytical structure is to see how Piano Marvel's mechanics, dynamics and aesthetics support piano learning contents or goals.

##### **Mechanics**

The obvious mechanics found in Piano Marvel are also the progression mechanisms. The main feature of this kind of mechanism is about level design which "dictates how a player can move through the game world." (Adams 2012) As piano learning involves a lot of music theories and techniques that students need to digest and know how to put it into practice. Facing a huge piano knowledge system, developers divide the curriculum into the Method section where students accept essential playing skills and the Technique section where students are going to enhance what they mastered in the Method section and apply skills in actual playing accurately to show the teaching contents clearly. Each section contains six predesigned levels and each level is divided into 6 increasingly difficult sub-levels from A to E while each sub-level is further broken up into 20 easy-to-handle lessons with clear missions and acquired skills statements. Learners can get a sense of progress when they complete the number of tasks and see the victory condition. Besides, different abilities in piano performance are stressed and used as keys in progression design. This game design strategy is to control a player's progress by granting their advanced abilities gradually. To humanize the app, learners are given the right to choose levels freely according to their piano foundation no matter whether they are beginners or intermediate players. All of them can find appropriate level courses easily and then to follow the arrangement of course tasks directly step by step. Another mechanism-social interaction is designed in Piano Marvel. Piano marvel will hold some competitions among users regularly to increase the communication of different piano learners. After completing a task, learners can check world ranking.

##### **Dynamics**

Certain types of dynamics must be designed to correspond with certain types of learning content and learning goals. Designers developed three tools to achieve different teaching objectives: prepare mode, assess mode and practice mode.

Assess mode is the application of a fast-paced game dynamic. **Assess mode** gives learners scores and feedback after finishing it. This mode can be also regarded as a test as the playing would not stop if students made mistakes which can increase the accuracy and fluency of executing a playing skill. Using this feedback students can quickly correct unnoticed mistakes before they turn the bad habits. Green notes show students what they play correctly and red marks show mistakes.

Prepare mode and practice mode are the reflection of deliberate and slow-paced dynamic. **Prepare mode** helps students learn the notes and note patterns in the most efficient and effective way. Under this mode, when students learn the notes of a song if they make mistakes, the red marks will appear to help them make corrections. After playing through the exercise, students will get a notification showing important feedback about their performance in this piece. This information will guide students through any song that they are learning. Once they are given an estimated score around a hundred percent, they will know it's time to use the asses mode. **Practice mode** unleashes one of the best-kept piano secrets of all time. This is the same technique used by piano teachers around the world. If students meet some difficulties in playing a piece. Practice mode breaks down challenging music into smaller sections that are easier to learn. With the practice mode, students can practice like the pros and learn harder music in less time.

The image shows a screenshot of a music learning application interface. At the top, there is a blue navigation bar with a home icon, the text 'Library', 'Fur Elise', 'Whole', and '3. Fur Elise', a timer '03:04', and the name 'Josh Mills'. Below the navigation bar is a piano score for 'Fur Elise' in 3/8 time. The score is displayed on two staves (treble and bass clef). The first staff starts with a 'pp' dynamic marking. The score includes various musical notations such as notes, rests, and slurs. A vertical blue bar highlights a specific section of the music. Red arrows point to specific notes, indicating mistakes. A small blue circle with a white icon is located in the bottom right corner of the interface.

Figure 4.3. The Feedback of Prepare Mode

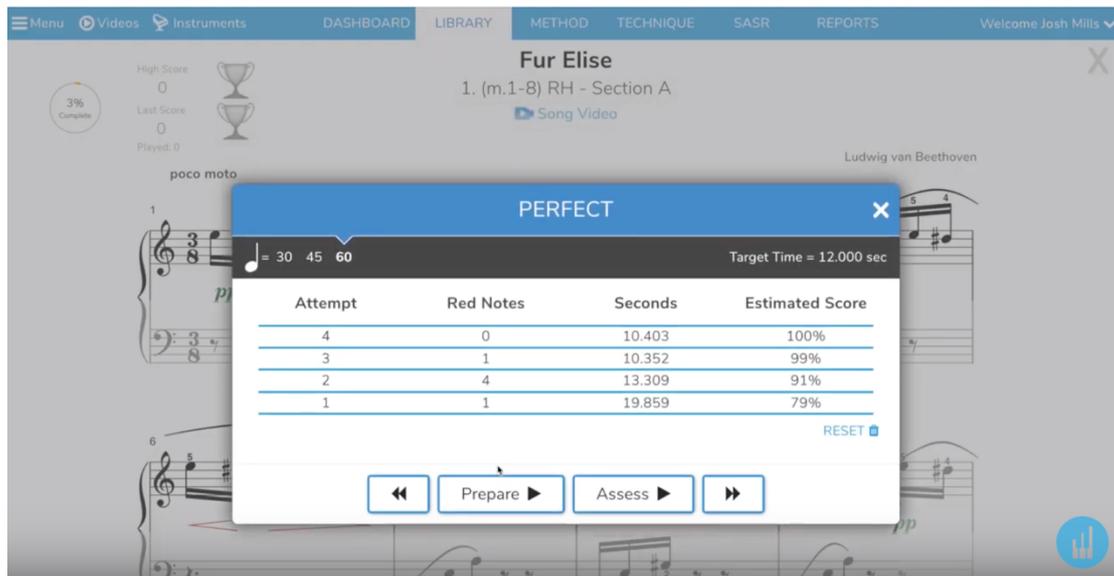


Figure 4.4. The Feedback of Prepare Mode

## Aesthetics

Piano Marvel contains a variety of expressions and "components of fun" that the users encounter during learning (Kim 2015). The challenge aesthetic is closely associated with this app. The feature of the trophy case is designed to increase the difficulty of learning piano and encourage students to reduce performance mistakes. In order to get a trophy in their trophy case, what they need to do is to pass off all twenty songs in any one of these trophies. If they want to get a golden trophy, they need to get at least 96 percent accuracy. If they want to get a golden trophy with a star on it, every one of the songs needs to have a hundred percent. Besides, once they have passed off a few songs they can go back to the dashboard, click on the ranking tool and see what their progress is worldwide against all of the Piano Marvel users in the world. This ranking system can inspire people to practice every day to improve their world ranking and increase what club they are in from the 10K club, 20K club, 30K club, 40K club, 50K club and onto the Master club in the technique section.

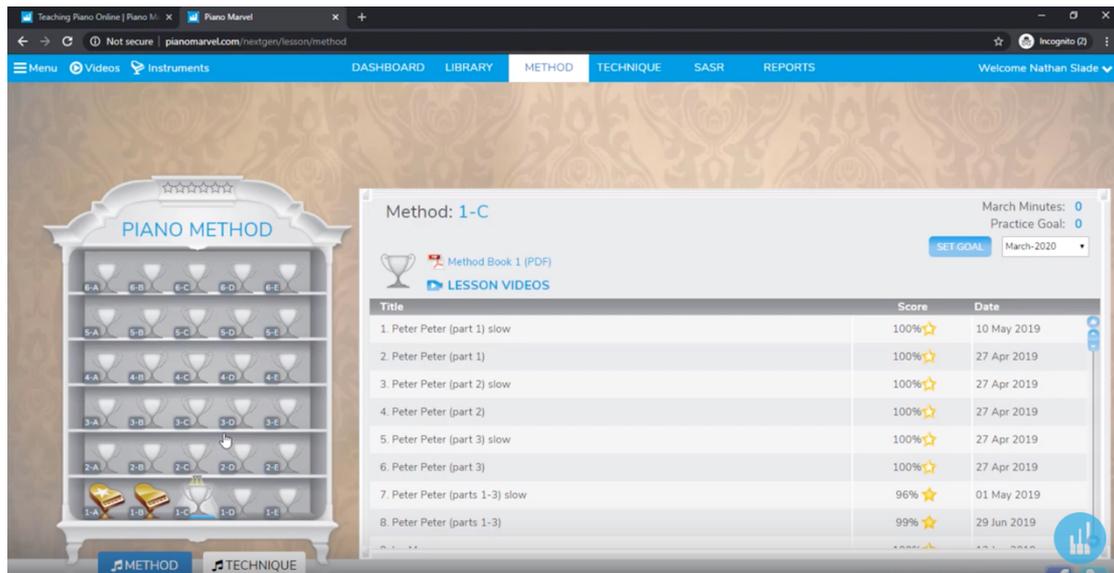


Figure 4.5. The trophy case of users

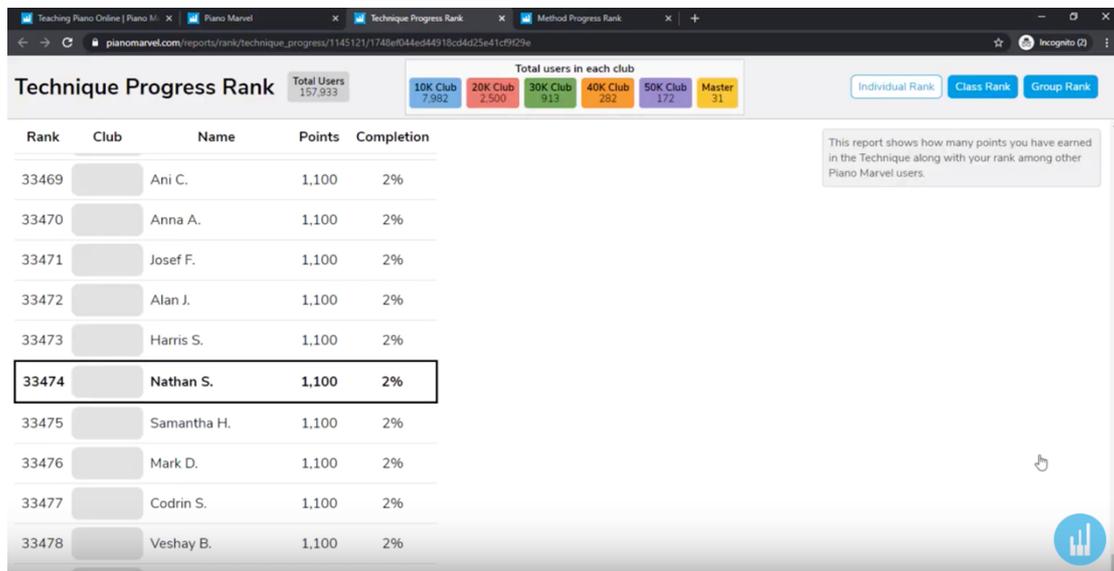


Figure 4.6. The ranking system and club indication in Technique section

Sensation (games as sense-pleasure) is the secondary aesthetic element. Teaching activities in Piano Marvel highly simulate real piano teaching. A series of elaborate designs including professional piano teacher demonstration videos, regular sheet music, printable piano textbooks is beneficial to create an immersive environment where users can enjoy a real piano studying experience and the feeling of being guided by a real piano teacher.

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8	Quarter Notes 		
9	C Song 		
10	Not the C Song		
11	Whole Notes (R&L) (Switching Hands)		
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15	C Song (R&L)		
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PAGE	METHOD 1B	SCORE	DATE
22	D Song 		
23	CDC Song		
24	B Song 		
25	CBC Song		
26	CB Song 		
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28	DCD Song		
29	Hot Cross Buns 		
30	Merrily We Roll Along		
31	Jazz 		
32	Fandango 		
33	Middle Landian CDE		
34	Agent ABC		
35	1B Review		

PIANO MARVEL

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Figure 4.7. The Printable Piano Textbook

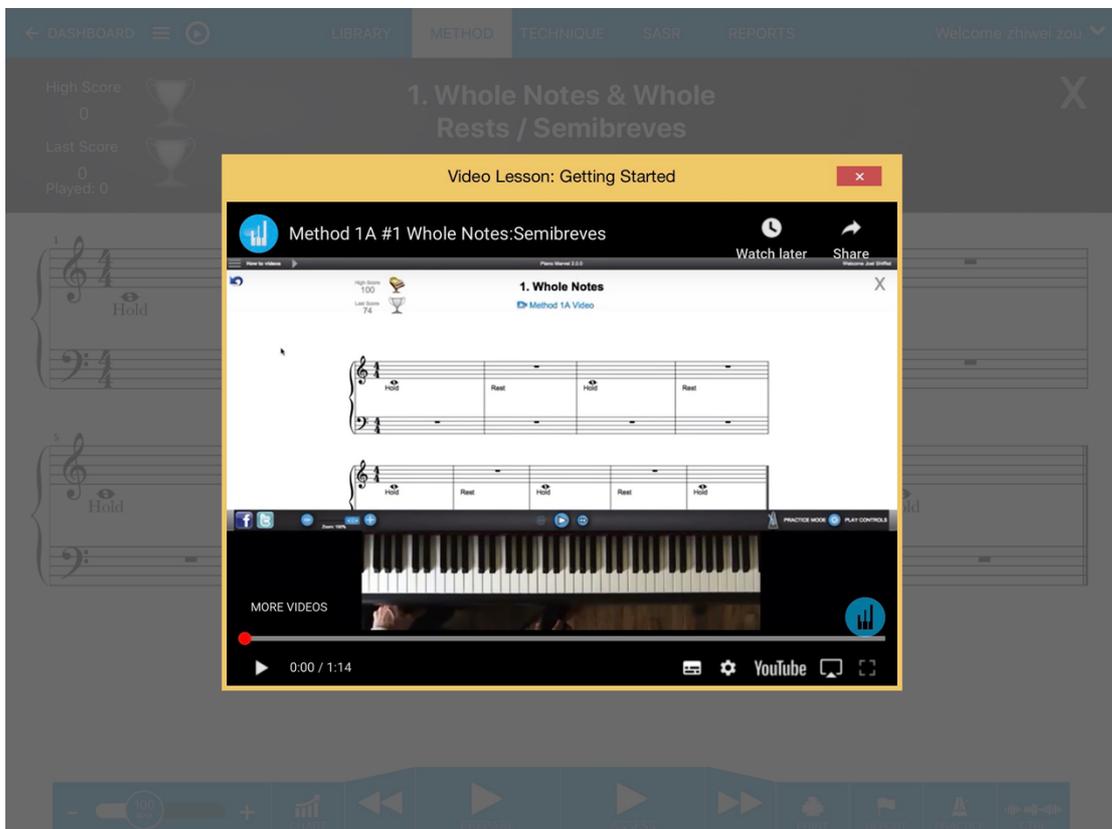


Figure 4.8. The Professional Piano Teacher Demonstration Video

The third aesthetic value connected with Piano Marvel is submission (gams as pastime), this app created a reports function to record piano learning progress of every student so they clearly know their practice minutes, recent 7 days practice situation and how to make their future study plan. They may also have the feeling their pastime is to achieve elegant interest.

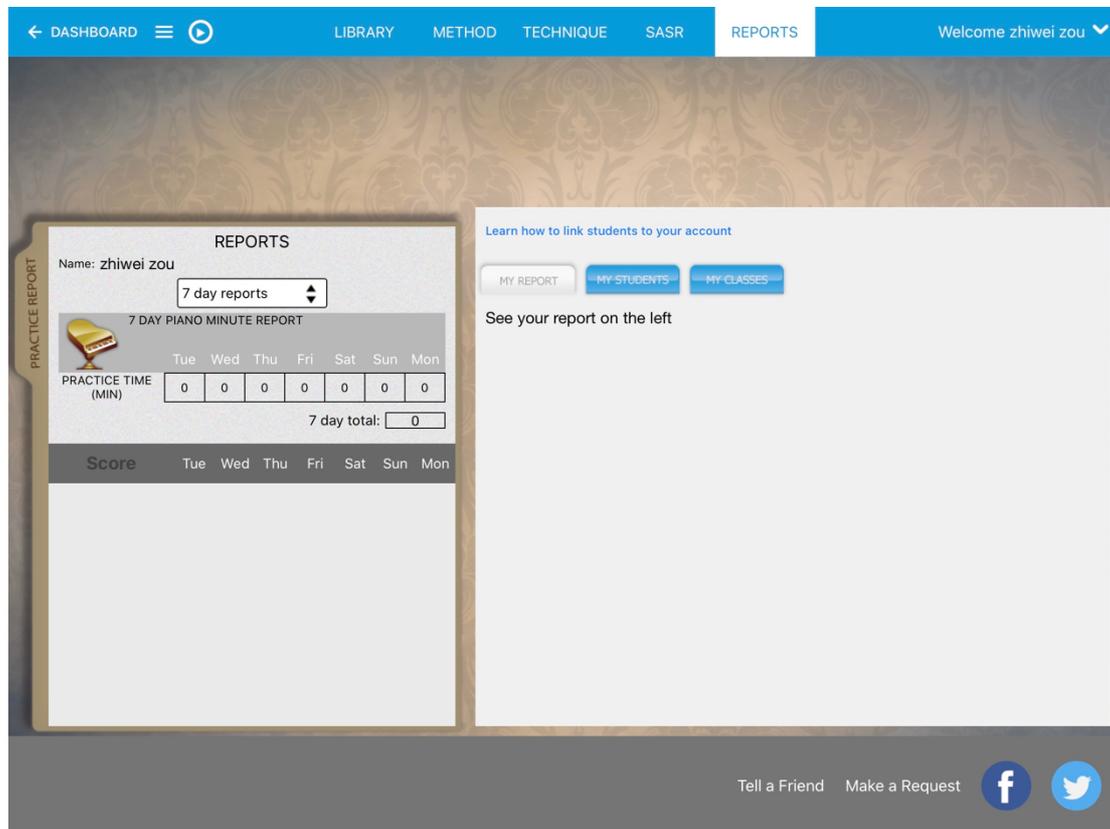


Figure 4.9. The reports of students' learning condition

#### 4.4. Instructional design principles

Several research-based principles from collections of the Life-Long learning principles and Jim Gee's 36 principles are adopted in the instruction design of Piano Marvel. Obviously, this app pays more attention to students' practice as they specially designed the "technique" section to help learners consolidate the knowledge from the "Method" section. This curriculum arrangement obeys the LLL#9"Coherence Effect: learning materials should be coherent and well-connected. Besides, the library is where students go to learn performance pieces or find even more songs and exercises to practice. There are literally thousands of songs in the library ranging from classical music to pop favorites and this app even offers the ability to upload their own music. Furthermore, on the home screen, users can track their practice minutes and a streak and those are motivational and informational pieces that give students an idea of how much they have actually been practicing and they can set the practice goal for the month. The day streak just shows students how often they are playing to

encourage students to keep practicing every day. Thus, Piano Marvel implements Gee#12: "Practice principle" which advocates learners should be given lots of practice.

A variety of learning materials are created to support students including formal printable textbooks, professional pianist demo videos, sight-reading tests "so that information gets delivered in multiple modes, modalities, and media". By observing pianist performance, it would be easier for them to understand and imitate correct fingering. The reasonable finger-keyboard relationship allows students to play logically, regularly, methodically. Written textbooks are beneficial to help students organize and summarize what they have learned. These instructional designs are relevant to LLL#2: "Perceptual-motor Grounding: Building new concepts in perceptual-motor experience can facilitate comprehension and later use of information" and LLL#3: "Dual Code and Multimedia Effects" using auditory, visual or media to present learning contents.

Despite Method section and Technique section's tests and library songs practice, SASR (Standard Assessment Sight Reading) is a special feature of Piano Marvel to quantify students' ability to sight-read and track their growth over time. There is lots of reading exploring for beginners or advanced players. Thus, Simply Piano instantiates LLL#4: "Testing Effect: Frequent tests can strengthen memory and familiarity and guide their future learning direction." and LLL#11: "Multiple Examples: Multiple and varied examples are used to help the understanding of an abstract concept." as well as Gee#26 "Bottom-Up Basic Skills Principle: Repeating basic skills in many games."

After finishing the whole playing, students will receive a score and the feedback system will indicate students missed measure or late measure with red marks. Students also need to click the notes to see where it is on the keyboard. Instead of correcting learners when they make mistakes and giving them correct indication directly, the feedback system of Piano Marvel tends to enhance the continuity of playing, improve performance overall and reduce their dependence on the aid of feedback. Thus, LLL#12 "Feedback Effects: the timing of feedback should be scheduled appropriately." and Gee#27 "Explicit Information On-Demand Just-In-Time Principle " are related to the instructional design of Piano Marvel.

Trophy case of Piano Marvel is an award system to encourage students to reduce mistakes and pursue perfect performance. The reward design has different levels including gold, silver and bronze trophies as well as the highest gold trophy with a star on it which can give students a sense of achievement and inspire them to progress from easy to hard. This reflected the Gee#11 "Achievement principle: being rewarded for achievement." and Gee#24 "Incremental Principle: being led from easy standards to harder ones".

#### 4.5 Combining components to (re)design ideas

- Learning objectives focus

Although Piano Marvel advertises their piano courses is aimed at beginners without piano foundation their basic intro to the piano is not enough to help students build a fast understanding of Piano as the first lesson is to require students to learn whole notes and whole rests/ semibreves directly not mentioning, barely touching hand position and posture.

- MDA focus

The interface of Piano Marvel includes too many choices that may be confusing for many novices who do not have a clear understanding of their piano level as Piano Marvel does not guide how to follow its series course and the use of tool sight-reading.

- Instructional principle focus

Piano Marvel has provided an advanced feedback system for learners but students will be notified of their playing accuracy after finishing the whole piece. For some learners who want to receive correction when they are playing, such kind of feedback mode cannot fulfill learners' needs. The better way to deal with this problem is to give students different choices about the operation way of the feedback system.

## Chapter 5 – Flowkey

### 5.1. Introduction to the app

Flowkey is a multi-platform for piano learning. Users can quickly and easily install it directly to PC or Mac, or Android/ios smartphones or tablets and they can use a professional acoustic grand or upright piano, or a portable keyboard that can be plugged directly into learners' devices. Their device's microphone will pick up notes from performance equipment and then make the judgment to provide feedback.

The app is \$19.99/month and has cheaper options depending on how long your subscription lasts. This is much more affordable than learning from a piano teacher, whose average prices range from around \$35-50 per hour.

It is an excellent and friendly tool for beginner learners as it includes beginner, intermediate, advanced and pro pieces that cater to students with different piano performance levels. Students can start playing their favorite songs right away and learn everything about notes, chords and the proper technique. Flowkey will show students exactly how to play each note and check if they play along correctly. This will make their practice a lot more effective and ensures long-term progress.

### 5.2. Learning objectives

<b>Introduction to the Piano</b>	
<b>First steps</b>	basics of the piano as well as Beethoven's famous Ode to Joy.
<b>Easy songs for the right hand</b>	playing some simple tunes in the C position to get the bearings at the piano
<b>Intro to reading sheet music</b>	learning the names of keys and the basics of musical notation
<b>Playing with the left hand</b>	how to play with the left hand with the song "Aura Lee"
<b>Notes of the bass clef staff</b>	learn the note values of quarter notes, half notes and whole notes
<b>Note value and rhythm</b>	improve rhythmic skills
<b>Rhythm practice</b>	discover and play more notes in the treble clef staff

Table 5.1. The contents of introduction to the piano course

With the support of the analytical framework, the learning objectives of Flowkey can be identified as follows. First, regards to the prior knowledge(question1)

that students need to equip, this is a beginner-friendly app. Although it includes intermediate and advanced pieces, the overall is aimed towards players who are not yet comfortable or familiar with reading sheet music. The curriculum arrangement reflects this feature.

- To narrow the knowledge gap, introduction to the piano in the courses section is designed to assist novices who want to quickly learn how to play the piano. This module would benefit absolute beginners to build a fast and basic understanding not limited to their previous piano foundation. Specific teaching content is showed in table 5.1.

With this intro module, the limitation to begin learning the piano is greatly reduced.

Question 2 is to stand in the position of learning and retention. There are comprehensive courses and lessons included, ranging from an introduction to the piano for a complete beginner, that covers posture, hand position, etc., to courses on how to play with both hands, how to play chords, even how to improvise that all skill levels learners can find what they want to learn in there. Flowkey currently provides 8 module courses and each module contains 5-12 courses. Each course is divided into small sections that are easy to follow. Video instruction about key theoretical knowledge and relevant exercises constitute each section.

<b>Curriculum of Flowkey</b>
Introduction to piano
Playing with both hands
Intermediate piano playing
Mastering chords
Improvising with chords
Music reading training
Playing scales
Playing scales 2

Table 5.2. The curriculum of the piano course arrangement

The excellent course feature of Flowkey is at teaching scales. It has specialized playing scales modules that cover all of the different scales at once. This systematic instruction in scales is beneficial for students who just want to practice their technique and memorize scales which is very important for reading sheet music. Then Flowkey would be the way to choose. Flowkey is

also best for chords as they talk about both three-note chords and four-note chords that simply piano have not touched upon four-note chords.

Finally, as for question3, potential transfer, skills, and knowledge instruction tend to help students acquire the potential composition ability. This technique is built upon a deep understanding of notes, rhythms, chords that the courses involve. Strictly speaking, the app does not require skills of composing, nor does it reward students for mastering it. Nonetheless, a bright student may learn the skill by following the course. However, Simply Piano provides no direct support for the art of writing music. Therefore, this kind of deficiency can be regarded as a transfer which means "they go beyond what is practiced in the game". (Aleven 2010)

### 5.3. Mechanics, dynamics and aesthetics

The MDA structure is going to explore how Flowkey's mechanics, dynamics and aesthetics assist the display of the course materials.

#### **Mechanics**

The design of mechanics in Flowkey is also the progression mechanism that offers learners "a structured environment and an orderly progression of goals as part of the experience". (Adams 2012) As piano learning contains an abundance of sheet music knowledge and performance techniques that students are expected to acquire. Therefore, the course director arranges the course section to assist teaching and each lesson contains different performing tasks that are "paced correctly so as to create a suitable difficulty curve to keep the learners both interested and challenged". (Adams 2012) Also, to provide students a sense of progress, Flowkey defines accurate progress in learning by setting a victory condition that users can actually achieve and a percentage that learners have completed.

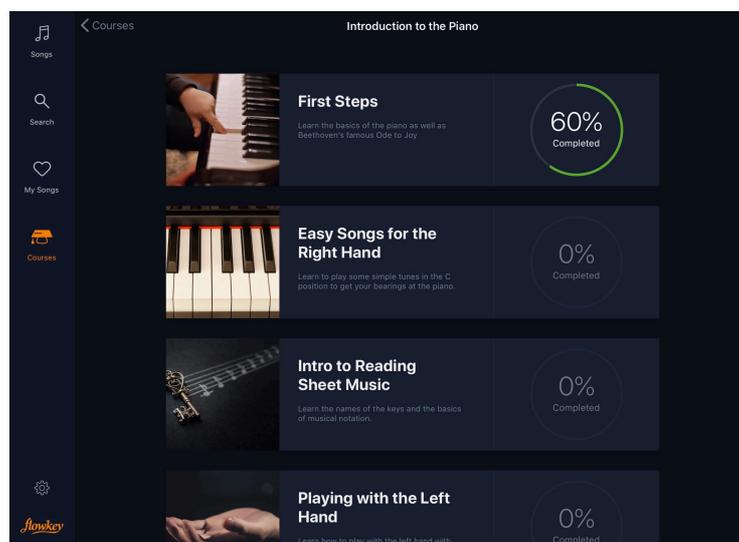


Figure 5.3. The interface of introduction to the piano section

Certain types of dynamics can speed up the process of learning a new piece. Flowkey features two special learning modes that allow learners to choose to help them practice including: "wait mode" and "slow mode".

- Under wait mode, people can choose to set the Flowkey pianist to play at 50% speed or 75% speed so it is easy to check their learning conditions. As students become familiar with the piece, they can increase from 50% to 70% and then 100% to test whether they can play the piece fluently.

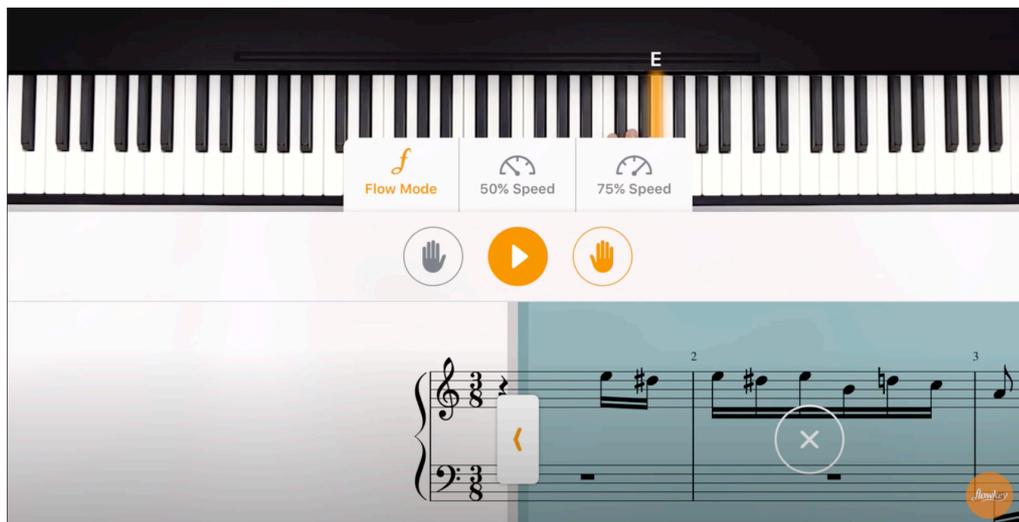


Figure 5.4. The interface of Flow mode

- As the name suggests, in wait mode, Flowkey will listen to their playing and wait at each note until they hit the right keys. This is quite useful for the beginning stages of learning a piece. It also allows students to select small sections of the piano to practice repeatedly as much as time as they need to learn the selected section before moving on. This feature can actively help students form helpful and productive practice habits without realizing it.

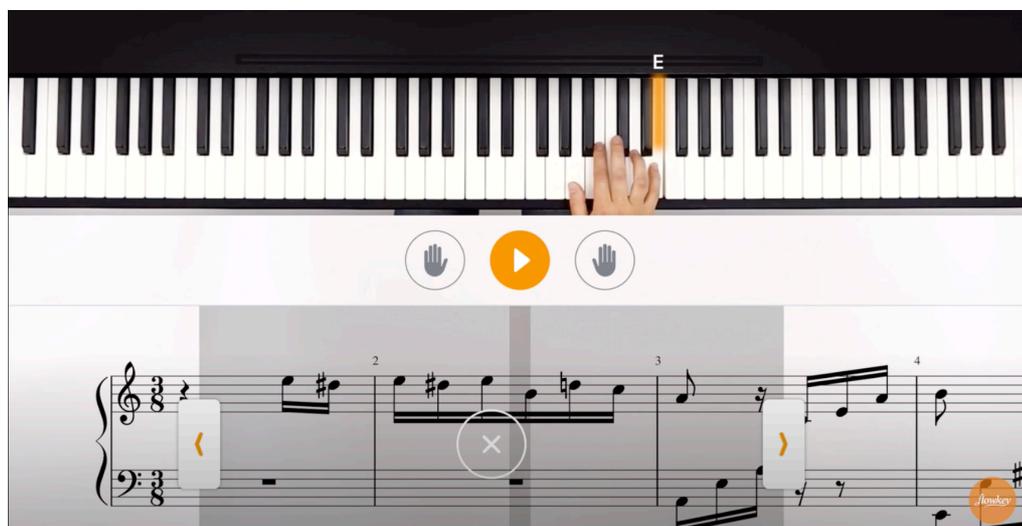


Figure 5.4. The interface of wait mode

## Aesthetics

Challenge is the primary aesthetics. The progression bar clearly shows how much did students learn which makes students urge to finish the course to master the corresponding piano technique. After-class exercises with different difficulties boots courses' replay ability. In addition, Songs are divided into beginner, intermediate, advanced or pro that students can select according to their skill level which can encourage people to accept new challenges continuously.

Submission (Game as a pastime) is closely related to the aesthetics of Flowkey. The most impressive feature of Flowkey is it contains a variety of songs in different categories and genres over 1500 songs included which is difficult for learners to run out of the playlist. In my personal experience, a beginner learning the piano with an experienced teacher will find that they are limited to the choice of pieces without any say in the matter. This often leads to students becoming frustrated and unmotivated because they have no passion or interest in this piece while teachers don't agree with students' choice often citing that "it's too hard" or that "this won't feature in your exam". Flowkey provides students the complete freedom to choose which piece they want to learn. Therefore, students tend to take piano as a relaxing and entertaining activity to kill time and are willing to spend more time in it.

Flowkey Song Categories			
Pop Hits	Classical Music	Film & TV	Romantic
Game Music	Jazz	Melancholy	Evergreens
Happy	Rock	Partners	Groovy
Kids	Traditionals	R&B	Energetic
Mellow	Christmas	Asian Pop	Smooth

Figure 5.5. The categories of Flowkey songs

Sensation (game as sense-pleasure) is the third aesthetic element. Flowkey simulates a real piano teaching environment by providing students with a video of a professional pianist playing, along with sheet music and highly-restored sheet music.



Figure 5.6. The interface of Flowkey songs

#### 5.4. Instructional design principles

Flowkey also adopted research-based principles from collections of the Life-Long Learning principles and Jim Gee's 36 principles in the instruction design.

This app focuses on delivering information in multiple modes. The learning interface is split into the video of the pianist performing and the sheet. There is a bird's eye view over the pianist which allows students not only to see the notes being played on the piano but also can help with what fingering to use. The reasonable finger-keyboard relationship is the core of training at traditional piano education and most teachers believe that correct fingering is even more important than playing the right notes. This instructional design is relevant to LLL#3: "Dual Code and Multimedia Effects" using auditory, visual or media to present learning contents.

Obviously, this app also pays attention to students' practice by providing different practicing modes and abundant thousands of pieces in the library for them to learn. Further, on the screen, users can track their progression of course and songs that give students an idea of how much they have actually been practicing. Thus, Flowkey implements Gee#12: "Practice principle" which advocates learners should be given lots of practice.

#### 5.5. Redesign ideas

- MDA focus  
Developers can tend to consider the mechanism of social interaction by holding some challenges each week for different levels of players, which

can also enhance the aesthetics of challenge and the sense of community. After participating in it, providing students with a ranking and a trophy can cultivate a sense of achievement.

- Instructional principle focus

This video of the person playing takes up so much space and sometimes students may end up looking at that instead of at the notes and that's not going to help them be able to read sheet music. Developers can take providing learners with different choices into consideration like video only, sheet music only or the combination of video and sheet music. This reflected LLL#3Dual Code and Multimedia Effects: "the amount of information should not overwhelm the learner because attention is split or cognitive capacities are overloaded."

Although this app has the function of instant guidance and feedback in the process of playing, the app can try to provide a precise practice conclusion like a score or correct rate after finishing a piece instead of a general conclusion which is not helpful for students to learn about their learning conditions.

## Chapter 6 – Comparative Analysis

This chapter tends to present a comparative analysis of Simply Piano, Piano Marvel, and Flowkey. Under the framework proposed by researchers from Carnegie Mellon University, they are compared regarding three components: learning objectives, Mechanics, dynamics, aesthetics, and Instructional Design Principles. The intention of this analysis was to identify what educational qualities that enable a piano teaching app as strong learning tools and make a summarization about elements that good-design interactivity of intelligent piano education applications should include.

### 6.1. Tabular Analysis- Learning Objectives

	<b>Learning objectives</b>
	The prior knowledge
Simply Piano	Not required
Piano Marvel	Not required
Flowkey	Not required

Table 6.1. Comparing the learning objectives-the prior knowledge

	<b>Learning objectives</b>
	Learning and retention
Simply Piano	It provides 27 different courses divided into two streams: soloist and chords.
Piano Marvel	There are two tabs labeled "Method" and "Technique"
Flowkey	Flowkey currently provides 8 modules courses ranging from an Introduction to the piano to Playing scales.

Table 6.2. Comparing the learning objectives-Learning and retention

	<b>Learning objectives</b>
	The potential transfer
Simply Piano	The skills or knowledge involved in this app may help students/users master improvisation.
Piano Marvel	Music theory and music history and literature involved in this app speculate that it helps users shape advanced music literacy of students
Flowkey	The skills and knowledge instruction tend to help students acquire the potential composition ability.

Table 6.3. Comparing the learning objectives-the potential transfer

As table 6.1 shows, all of the apps claim that they are novice-friendly and no prior knowledge or skills about piano are required. To lower the threshold for entering into the piano, developers provide a series of orientation courses or introduction courses to equip beginners with basic skills which will serve as a foundation for the future learning journey. This can attract more absolute beginners who have huge enthusiasm in piano but worry about it is difficult for them to learn without the support of previous relevant experience and make them not overwhelmed by it.

In terms of the curriculum contents, Simply Piano has two streams. **The soloist track** focuses on playing melodies, expanding your note range and polishing up your technique. **The chords track** focuses on learning how to accompany songs of all genres, the fundamentals of playing chords for well-known pop, rock, and jazz songs and different styles of accompaniments. Piano Marvel has two sections "Method" and "Technique" where students want to go to build and strengthen their basic skills of piano play including scales, arpeggios, sight-reading, ear-training, harmonization and cadences. Flowkey currently provides 8 modules courses ranging from an Introduction to the piano for a complete beginner, that covers posture, hand position, etc. to courses on scales, how to play with both hands, how to play chords(three note chords and four note chords that Simply piano didn't mention), even how to improvise

From the course contents, we can speculate that most learners are more likely to acquire familiarity with, fluency with, deep understanding of reading sheet music, specific notes, intervals, chords, rhythms, playing their favorite songs and hand coordination skills. It is worthy to consider covering the knowledge of different scales in one section systematically which is helpful to memorize scales and improve the efficiency of reading sheet music. These comprehensive instructional courses enhanced the professionalism of online piano teaching. However, only Piano Marvel adds extra tests of ear-training which is an important basic course in piano learning to develop a more intuitive understanding of what they hear and sight-reading tests which is the foundation of piano performance.

As evidenced in Table 6.3, what was originally considered as transfer provides a new perspective to expand the learning objectives. App developers can consider whether they can bring improvisation, composition, and music literacy into the game.

Therefore, to strongly implement the learning objectives, the intelligent piano education app should:

1. Provide essential piano conversion courses to beginners including: correct sit and hands positions, the basic notes- middle C,D,E,F,G intro to reading sheet music, note value and rhythm.

2. Provide extra specialized tests or practices of ear-training and sight-reading in spite of providing chords, notes, scales, rhythms...
3. Cover four note chords for catering for different levels learners
4. Consider covering all scales in one section to increase the systematic and continuity of knowledge.
5. Consider expanding learning objectives like improvisation, composition and music literacy.

## 6.2. Tabular Analysis-MDA Structure

<b>MDA Structure</b>			
<b>Mechanics</b>	<b>Simply Piano</b>	<b>Piano Marvel</b>	<b>Flowkey</b>
Progression	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Social	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Goals	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Scoring system	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Feedback loops	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Timer	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Music Library	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Audio, video and visuals	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 6.4. Comparing the MDA Structure-Mechanics

<b>MDA Structure</b>			
<b>Dynamics</b>	<b>Simply Piano</b>	<b>Piano Marvel</b>	<b>Flowkey</b>
Time pressure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Competition	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Achievement	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Constraints	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 6.5. Comparing the MDA Structure-Dynamics

<b>MDA Structure</b>			
<b>Aesthetics</b>	<b>Simply Piano</b>	<b>Piano Marvel</b>	<b>Flowkey</b>
Challenge	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Sensation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Submission	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 6.6. Comparing the MDA Structure-Aesthetics

Mechanics	Aesthetics			Dynamics			
	Challenge	Sensation	Submission	Time pressure	Competition	Achievement	Constraints
Progression	✓					✓	✓
Social	✓	✓	✓		✓	✓	
Goals	✓				✓	✓	
Scoring system	✓				✓	✓	
Feedback loops					✓	✓	
Timer	✓			✓	✓		✓
Music Library	✓	✓	✓				
Audio, video and visuals		✓					

Table 6.7. Comparing aesthetics and dynamics against mechanics

The selected three apps mainly adopted the progression mechanism that arranges the learning content in scientific sequence according to reasonable piano learning principles and dictates how a student can move through the different learning levels to cater to students' learning needs. Learners just need to follow the course stream and don't need to worry about where to start. The difference is in whether students can choose the lessons flexibly. Simply piano requires students to follow the app's learning progression which defines what tasks they must perform to proceed to next courses. This can enhance the challenging aesthetics. However, Piano Marvel and Flowkey provide students with the flexibility to choose courses which can meet learners with different goals and foundation of the piano.

The social interaction mechanism can be only found in Piano Marvel. Piano marvel will hold some competitions among users regularly to increase the communication of different piano learners. In addition, after completing a learning task, students can check their world rankings.

As piano performance involves an abundance of knowledge and techniques that students must acquire, exposing them to all these at the same time may lead to an overwhelming experience and speed up the loss of interests of learners. The clever way that app developers took to tackle this problem is to break it down in easy-to-handle chunks. Individual lessons especially have clear defined missions that set goals the learners are going to achieve and structure the tasks they have to complete so as to enter the next level. This can avoid students being overwhelmed by a lot of piano knowledge and technique.

Simply Piano and Piano Marvel provide an accurate scoring system after finishing a task but Flowkey only has a general conclusion for performance which cannot satisfy learners who are ambitious and pursue a statistical evaluation.

Three apps have the common function of instant feedback and guidance. It provides real-time feedback on the success of playing notes accurately or on the failure of missing notes. The main difference is in the time of occurrence. Simply piano and Flowkey correct learners when they make mistakes and give them correct indication directly which can speed up the learning process and reduce the difficulty to some extent. However, Piano Marvel tends to give students more thinking space. After finishing the whole playing, students can receive the feedback that indicates students missed measure or late measure with red marks, and they also need to click the notes to see the correct position in the keyboard. This mechanism can enhance the continuity of playing, improve performance overall, and reduce learners' dependence on the aid of feedback.

Simply piano and Piano Marvel set a strict time limit for recognizing notes and chords but Flowkey allows students to think until they hit the right keys. The timer can enhance the challenging aesthetic and develop faster sight-reading skills.

Three apps have excellent music libraries for students to learn and practice. It contains a variety of songs in different categories and genres from popular to classical which also have different versions from simple, intermediate, and advanced corresponding to courses that students take.

Although three apps have the awareness to use more audios, videos, and visuals to create a real piano teaching atmosphere, only Flowkey provides the video demonstrations of professional pianists to each song so that students can imitate the correct fingering. Besides, Piano Marvel and Flowkey choose the traditional visuals of music sheets to enhance the realism of piano learning.

Therefore, to strongly implement the MDA structure, the intelligent piano education app should:

1. Provide a well-organized course stream where people have to follow the course syllabus or choose the course freely.
2. Provide more piano competitions and word ranking system
3. Give students a clear goal that they need to achieve and the progression bar that shows how much students have finished or learned.
4. Provide accurate evaluation to students after finishing playing
5. Provide instant feedback for students' performance and the choices for the time of occurrence
6. Set a strict time for recognizing the notes and chords.
7. Provide a music library which collects different types of pieces for students to practice and different difficulty versions for learners with different levels.
8. Apply multi-media techniques to provide formal printable textbooks, professional pianist demo videos in the process of teaching.

9. Adopt traditional visuals of music sheet

6.3. Tabular Analysis-The Instructional Design Principles

Instructional Principle collection	Principle	Simply Piano	Piano Marvel	Flowkey
Life-Long learning principles	#02 Perceptual-motor Grounding	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#03 Dual Code and Multimedia Effects	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#04 Testing Effect	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#09 Coherence effect	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#11 Multiple Example	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#12 Feedback effects	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#21 Goldilocks Principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Jim Gee's 36 principles	#11 Achievement principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#12 Practice principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#14 Regime Of Competence Principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#24 Incremental Principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#26 Bottom-Up Basic Skills Principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#27 Explicit Information On-Demand Just-In-Time Principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 6.8. Comparing Instructional Design Principles.

Instructional Principle collection	Principle	Progression	Social	Goals	Scoring Systems	Feedback loops	Timer	Music Library	Audio, video and visuals
Life-Long learning principles	#02 Perceptual-motor Grounding	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#03 Dual Code and Multimedia Effects	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#04 Testing Effect	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#09 Coherence effect	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	#11 Multiple Example	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	#12 Feedback effects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	#21 Goldilocks Principle	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#11 Achievement principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	#12 Practice principle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#14 Regime Of Competence Principle	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	#24 Incremental Principle	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	#26 Bottom-Up Basic Skills Principle	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Jim Gee's 36 principles	#27 Explicit Information On-Demand Just-In-Time Principle	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Table 6.9. Comparing which mechanics support Instructional Design Principles

Table 6.8 demonstrates that Simply Piano, Piano Marvel and Flowkey implements a number of research-based instructional principles from collecting of the Life-Long learning principles and Jim Gee's 36 principles of game-based learning, as an important way of “bringing the learning sciences into the design of educational games” (Aleven 2010).

Table 6.9 reveals how a game’s mechanic supports learning and whether it is consistent with learning sciences. It also shows that the progression mechanic supports most of the learning principles.

To strongly implement the Instructional Design Principles, the mechanic of intelligent piano education app should:

1. Encourage learners to practice by providing ample skill tests and reminders of how often they have been playing.
2. Give students feedback by providing real time notification on the success or failure of playing notes as well as accurate scoring evaluation.
3. Use multiple examples to teach an abstract concept by collecting extra challenging songs as exercise for learners to practice.
4. design coherent learning materials corresponding to different learners’ levels and the internal course branches direct and easy to follow.
5. design the assignments in a reasonable difficulty gradually becoming more challenging as the learners advance through higher levels.
6. use auditory, visual or media to present learning materials.
7. guide students from easy standards to harder ones by arranging the learning content in scientific sequence from basics to advanced.
8. award players’ performance to inspire them to keep practice.

## Conclusion

Interactivity was analyzed in three intelligent piano education apps by using one framework. This was adopted for identifying what aspects of this type of apps made them become effective learning tools. This framework analyzed learning objectives, MDA structure, and instructional design principles.

Through comparative analysis, it is obvious to see that the main mechanics of these apps: progression, scoring systems, feedback loops, music library, and timer. The progression mechanic is the most versatile of all mechanics, as it encourages the achievement dynamic and makes the app teaching content well-organized. The dynamics that apps created to stimulate learners are time pressure, competition, achievement, and constraints. At the same time, the aesthetics created by the mechanics and enhanced by dynamics are challenging, sensation, and submission.

The instructional design principles are most clearly present in the progression mechanic. The feature of this kind of mechanism is related to level design which dictates what information is arranged in the app and how a player can move through the information. Facing a huge piano knowledge system, this mechanism would help lessen cognitive overload as well as keep consistent with the teaching scientific. The balance between cognitive overload and other learning principles is quite vital to keep the learners both interested and challenged.

Future work could focus on the redesign ideas of such apps from the three perspectives. It would be interesting to enhance learning objectives, discover more creative mechanisms, dynamics and aesthetics as well as adopt more instructional design principles.

First approach to generate redesign ideas is to consider its learning objectives such as how it can be enhanced or how it can be expanded. Specifically, developers can focus on how to help complete beginners narrow the foundation gap, how to fulfill more users' learning needs like "transfer" mentioned before to see whether it can be added in the course contents.

In terms of MDA, the starting point is to think of the enhancement or change of the game' aesthetics like fellowship (game as social framework). The next step is to make mechanics and dynamics support fellowship aesthetics such as double play, weekly competitions, joining teams.

The final source of redesign ideas is to bring more instructional principles into the teaching or modify the conducted principles. For example, in the implementing of LLL#3Dual Code and Multimedia Effects, the amount of

information should not overwhelm the learner because cognitive capacities are limited and attention may be split." LLL#3 also recommends that in the process of delivering new knowledge, more videos should be given to support students' learning.

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