Chapter 7

ENHANCING MUSIC PROWESS THROUGH ANALYTICS

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Abstract: Analytics is the study of context-aggregate and context-precise insights. These insights are derived from observed user experiences represented in computational scaffolds. The scaffolds allow both humans and software agents to continually validate and characterize the insights. In the setting of learning analytics, these insights trace, employ, analyze, discover, and foster learning traces toward conceptually-optimal, emotively-engaging, cognitively-efficient, and creativity-inspired learning experiences where a learning trace comprises of an instantiated network of models that lead to a measurable chunk of learning. While learning analytics platforms in general focus on the tracking and reporting of broad and generic learning activity events, new e-learning technologies as introduced in the setting of this research have enabled to apply analytics not only in learning in general but also in specific learning domains such as mathematics, English writing, and programming. Since music as a domain requires a high level of monitoring to guarantee learners' success, learning analytics will play a key role in helping music students attain optimal accomplishments. This chapter on music analytics discusses ways to enable teachers to listen whenever and wherever students practice instrumental or vocal music, to identify challenges encountered by students, to track the development of students' skills in solving music theory exercises, and to understand the causes for their successes and failures. This chapter introduces a music analytics tool called MUSIX to analyze the performance of students in terms of proficiency and confidence in music learning objectives and to promote self-regulatory traits to help them manage their own learning processes.

Key words: music analytics – e-learning – teaching approach – audio software – human-computer interaction

1. INTRODUCTION

Music is an art consisting of a suite of unique skills such as vocal singing, playing an instrument, understanding musical notation, and creating a musical score. Musical skills can be nurtured with sustained, adaptive, and goal-oriented instruction and practice, to meld into musical competences. Music teachers help shape the development of individual skills before the skills are honed as competences of musicians.

Traditional music teaching, however, caters only to a limited understanding of the music learning processes and learning challenges faced by students. Wise, Greenwood, & Davis (2011) state that "many secondary school music teachers are products of the Western classical tradition, which is based largely on the conservatoire and the associated skills and traditions that this brings with it" (p.121). That is, music teachers have limited opportunities and datasets to determine the needs of students in terms of individual skills. This is further compounded by the lack of information on the depth at which skills of individual students need to be nurtured.

One may contend that teachers could target instruction at a particular depth prescribed by taxonomies such as Bloom's (Rodrigues & Dos Santos, 2013). But, practicality of teaching indicates that gauging the depth at which students are toiling is an extremely difficult proposition. Such information typically arrives as outcomes of an assessment activity. Teachers also employ formative techniques such as in-class performance observations and group work to instruct students who lag behind targeted skill level.

This is where learning analytics plays a central role, in providing teachers with measurable, continuous, and detailed information concerning the development of individual skills in each student, from both formal and informal study sessions, including in-class, in-the-lab, and at-home sessions. Further, teachers can be made aware of the learning process adopted by students, including the challenges students encounter during each study session. Learning analytics system could also correlate study habits of students with the assessment outcomes, and prescribe optimal study pathways for individual students and advocate compatible pedagogies appropriate for each student.

A learning analytics tool for music, called MUSIX (Guillot, 2015), has been designed and is being developed to address these key challenges. This chapter offers a review of the traditional music teaching approaches and highlights the complementary music teaching approaches using MUSIX's analytics.

2. TRADITIONAL MUSIC TEACHING

While learning music is an immensely rewarding experience, it can also be at times discouraging. Some of the causes of such discouragement are discussed below.

2.1 Lessons to large groups

In many music schools, primarily, lessons are offered to groups of students. Playing music in group or singing with ensemble is a great asset in the training of a musician. However, the group approach does not bode well to detecting students' difficulties or determining the appropriate level of assistance to be provided to students in their daily routine of learning music since every student is unique with different learning capacities and preferences. Typically, students can be identified in one of these three categories: talented, average, or struggling.

Average students are not penalized much in group study or practice since they possess adequate study skills to achieve learning outcomes set forth by the teacher. But, difficulties experienced by the struggling students often go unnoticed. They would require more time and additional instructions to help them achieve the learning outcomes, but they tend to keep silent and not seek teacher's help, thus choosing to remain unnoticed and are inevitably left behind. It is clear that this phenomenon generates discouragement and it may create major gaps in the learning processes of students, even dissuade them to pursue further musical studies.

Talented students tend to accommodate instruction as provided and continue their levels of performance. They, however, can be slowed down in their learning process by the rest of the group. In such cases, this context tends to diminish their interest and attention which is also damaging to their possible future career as musicians.

Essentially, the group approach does not suit all students. However, individualized training and personalized instruction in music education should not diminish the importance of group study. Group study should be considered a significant part of the general music education.

2.2 Lessons with fixed time intervals

Another difficulty with the traditional music teaching approach is the system of lessons offered at fixed time intervals. It is mostly used in the case of individual lessons. Usually, instrumental lesson or voice training lesson are given once a week. Individual teaching is a great way (if not the best) to address the specific needs of a student; it can be advantageous because of the

one-to-one interactions between the student and the teacher. However, having only one hour a week to observe practice habits and growth of skills offers minimal information to the teacher thus leading to non-optimal instruction. This exposes a main concern about this approach. The teacher can assess and guide the student within a study session, but there is no monitoring of the student's study processes and achievements outside of the study session. When left alone to practice, the student can face challenges and be confused about the ways to address them. Maintaining a positive learning experience is rather difficult when the students try to resolve these challenges on their own (often in a wrong way) or ignore them.

2.3 Other disadvantages of traditional teaching

While the world is making huge steps in introducing technology-enhanced learning in many subject areas, music remains one of the few that are still taught in the old-fashioned way. Bauer (2014) describes that "while there is evidence that new, technology-based approaches may be increasing in some areas of music education [Williams, 2012], it appears many music educators are not actively utilizing technology in a manner that could potentially facilitate and enhance musical experiences for students."

As discussed above, traditional teaching could hamper the learning efficiency of students since the teacher is not aware of the difficulties faced by the students while they study music. That is, the teacher is only aware of the progress made by the students when they are assessed. Then, and only then, a small window is opened to the teacher about the learning process of his students. Beatty (2015) states that "the assessment and evaluation of students' achievement in music education remains central for the music teacher in determining the knowledge and skills that students have learned."

Traceable study efforts of students are only observed during individual instructional sessions, which represent only a small percentage of the whole music learning process of the student. The details that ought to be known by the teacher during practice time at home or with friends or anywhere outside the classroom are critically valuable and yet they remain unavailable to the teacher.

It is also important to note that some music training software already exist but they do not capture learning traces. Students do use technology to train themselves with whatever means available to them, including the use of a computer in learning music, but such efforts are never brought to the attention of the teacher.

3. MUSIX TEACHING APPROACH

MUSIX is a learning analytics system for the domain of music. It allows students to learn music at their own pace, and explicitly capture their growth in music competence and music confidence. Bauer (2014) aptly expresses that "the art and science of teaching by skilled educators involves making 'real time' instructional decisions, adjusting on the fly." Adhering to this philosophy, MUSIX, at present, only offers individualized approach to detect students' difficulties and to provide custom solution to these difficulties.

Motivation is one of the key aspects one should consider when exploring a new approach to teach music. Learning music should be facilitated in an atmosphere of enthusiasm and positive engagement. Such an environment should also allow students to express their concerns confidently and openly at a time and place of their choice. MUSIX provides multiple avenues of expression and learning for students and also provides the means to measure the statii of individual musical skills, the contribution of individual skills to competences, the confidence with which musical competences have been expressed, and the ability of students to regulate their own learning habits.

3.1 Capturing data on a continuous basis

MUSIX's goal is to track students' activities through instructional sessions, computer-based exercises, games, quizzes, social network interactions — all created within a learning management system —, and practice time. MUSIX aims to capture as much data as possible based on these activities and process them to recognize study patterns, to identify expressed skills, to predict the growth of multiple skills into competences, and to measure self- and co-regulation efforts.

Tracking of a variety of study related data is a main function of MUSIX since it is these datasets that will provide information that are normally not available in traditional approaches.

MUSIX aims to continually update the profiles of students as and when the datasets become available. The profiles could predict, on a daily basis, students who are lagging behind the rest of the class. The outcomes of such predictive models could be made available to teachers and also to individual students. Students, with assistance from teachers, can engage in self-regulatory and co-regulatory initiatives (see Section 3.6 below) to catch up with the rest of the class, thus avoiding being left behind with the knowledge that they are not alone in their learning process.

MUSIX is geared to collect activity-specific datasets. Presently, MUSIX collects data from the following three activities: study of music theory, vocal training, and the playing of an instrument.

3.1.1 Study of music theory

Many concepts of music theory are often misunderstood by students and a number of them consider theory as an optional area of study. But since the study of music theory "mainly deals with the language and notion of music where it is composed and interpreted" (Aldalalah, 2010), it has been proved that "these music concepts have an important role in establishing the necessary knowledge for interpreting the development stages in music and the mode in which the notation is utilized in various situations." (Aldalalah, 2010) MUSIX offers instructional lessons on music theory at different levels of mastery. The progress of students in theory lessons are continually tracked. Using such learning traces, progress of students are frequently updated. MUSIX collects a wide range of datasets including time-oriented datasets (e.g., time to answer question in a quiz, the type of hints requested, the amount of time spent reading a page, and the number of initiatives taken by the student). MUSIX allows tracing data on any activity of learner engagement. For example, if a game-based approach is used to introduce music theory, then MUSIX will enable the tracking of game-related activities of the student.

Music theory lessons are created and implemented in an online learning management system, allowing students to have flexible access to the content and study activities.

3.1.2 Vocal training

Vocal training in MUSIX presents an interesting challenge because not only one needs to capture raw audio recordings of students' practice but also needs to automatically interpret the recordings in terms of skills and the degree to which the skills have been exhibited. MUSIX offers two types of vocal training, first the sight-singing and second, the vocal techniques. These two are closely related but yet, they need to be trained separately.

In order to measure sight-singing performance of a student, MUSIX will first present a melody on the student's computer screen. It will also offer the student with an audio file that plays the note range along with other options such as "listen to the first note" and "listen to the beat measure" and so on. Subsequently, the student will have the opportunity to start sight-singing the melody and record the same. The student is welcome to record multiple times and each recording will be analyzed by MUSIX for accuracy of notes, correctness of rhythms, and appropriateness of pitch.

Under vocal techniques, MUSIX offers training on note accuracy, with a particular focus in the position of many body parts. Singing techniques are improved with good breathing, position of the mouth, appropriate muscle tension, and more. Since the whole body is transformed as an instrument,

physiology datasets corresponding to specific body parts will be sensed and recorded. An experienced teacher will quickly detect a bad technique by looking or by sensing the throat muscles as the student sings. In addition to such physiology datasets, MUSIX will also record information on students' breathing, delays before breathing, the tuning of each note, the duration of the notes, and other similar data.

3.1.3 Instrument playing

Teachers opt to be by the side of their students as they practice their instruments. Discovering how a student practices is a mystery to most music teachers. In unfolding this mystery, MUSIX will capture data such as the timing of a student's instrument practice, the breaks in between practices, the sequence of the practice, the manner with which the student handled errors, the mastery of concepts learned in a lesson, and the number of notes played correctly. McPherson and Renwick (2000) pointed out rightly that "how children plan and manage their time has important implications for how efficient their practice will be".

MUSIX records all possible study activities with respect to time, accuracy of notes, accuracy of rhythms, and other such valuable data. Music related data uses a MIDI connection between a digital instrument and MUSIX in order to transfer converted data. For instance, the digital piano may send many datasets on the notes played, speed at which melodies are played, the articulations of notes, and the rhythms. Other instruments such as a silent violin or an electric guitar will also be capable of transmitting data to the MUSIX software. All music notes will be transformed and sent to the analysis engine in MusicXML format.

3.2 Analyzing music data

Captured data are automatically sent to a database and then onwards to an analytics engine. The analytics engine offers a number of custom solutions specific to the requirements of each student or each class. Example analytics solutions include measure of students' level of understanding of music theory, models that mimic the challenges students faced in playing an instrument, and the capacity estimates on specific singing techniques.

MUSIX can detect, for example, a specific music theory topic that is not understood by a student, the tonic and the dominant notes that are well tuned for a student, or types of errors made by a student playing a piece in piano.

The analysis engine is the brain of the MUSIX system. It has the ability to parse the incoming data, at real time, and offer insightful information to the

teacher and students with respect to individual music skills. Analysis will be made on the level of confidence of a student pertaining to target skills.

3.3 Focusing on strengths and weaknesses

MUSIX has the ability to identify weaknesses of students as well as their strengths. Ethically valid monitoring of students gives them confidence because they know that the system will identify any misconception that needs timely remedy.

MUSIX, in addition to identifying weaknesses, also identifies positive advances students make at higher levels of granularity. Students tend not to see their performance at higher levels of abstraction. Their natural tendency is to tackle tasks that still need to be achieved and adjusted.

3.4 Giving feedback and guidance

MUSIX is valuable in precisely identifying student difficulties, conceptual issues faced by the student, and remedial activities that address the difficulties and issues. Students receive real-time feedback in relation to their answers to exercises, their play moves within a music game, or the quality of their notes in voice recordings. Continuous guidance is reassuring for students as they do not feel alone in their learning process but rather see that they are guided through specific steps and exercises to overcome their personal challenges.

If MUSIX detects the struggles of a student with respect to a specific learning facet, it has the means to offer alternative study pathways, in terms of additional hints, instructions, games, and quizzes. MUSIX lessons are designed based on the theory of experiential learning (Lee, Barker, & Kumar, 2011), allowing students to select the medium and mode of study that suit them, as depicted in Figure 1.

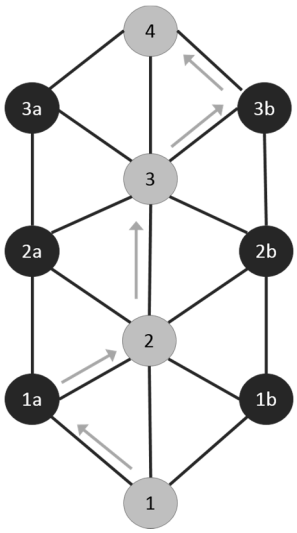

Figure 1 – Theory of experiential learning

3.5 Displaying interactive data

MUSIX has a dashboard that shows data being captured, explains the transformation of data, and interactively visualizes analysed data. Visual representation helps to locate study trends and gaps in the learning process. The dashboard is accessible to students, teachers, parents, and others involved in the music education development.

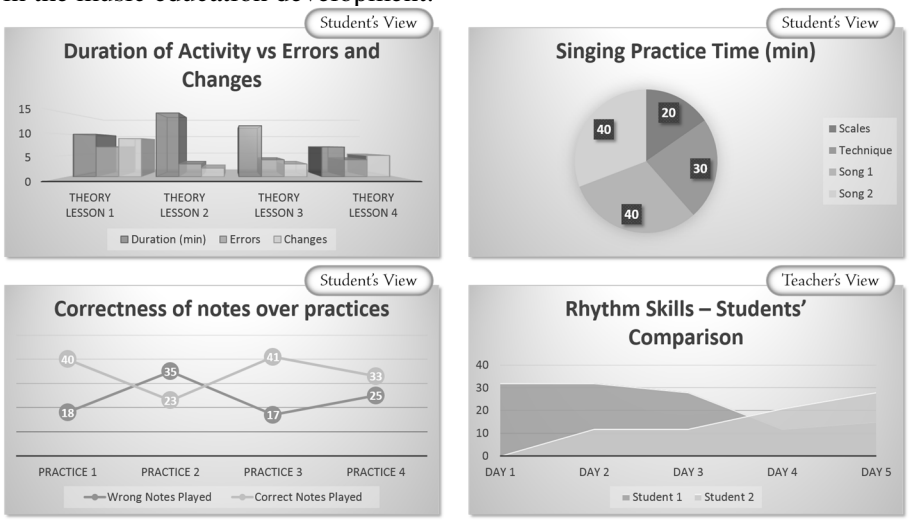

Figure 2 - Example of visualizations offered in the MUSIX dashboard

The teacher's view allows teachers to have an overall view of performances of their entire class at the same time, identifying students struggling with music concepts compared with the average performance of the class. The class average option is also available in the student's view to enable students compare their progress with classmates.

Overall, the student will be able to see, in real time, study material, concepts, and competences that have been mastered as well as gaps in their knowledge.

3.6 Encouraging self- and co-regulation

Self-regulation are co-regulation are features in MUSIX that target student motivation and positive engagement. In self-regulation, students set their own goals corresponding to a set of skills, identify study strategies to accomplish tasks leading towards mastery of these skills, measure the success of the goals, and adapt study strategies to accomplish the goals. These activities, setting of goals, picking of strategies, and executing and adapting plans, are termed as initiatives. Students can monitor their progress with respect to each initiative. Typically, students create initiatives as part of their interactions in the dashboard. The MUSIX system will continually and automatically update the parameters of each initiative, thus allowing students to engage explicitly with their own study.

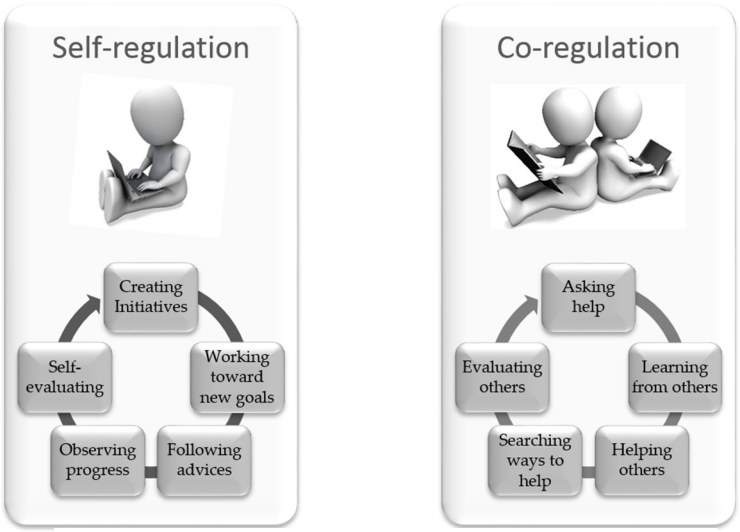

Figure 3 - Elements that are part of self- and co-regulation

Co-regulation is also a key feature in MUSIX where initiatives are created, monitored and modified by people other than the student. The social aspect of

co-regulation that involves friends, peers, teachers, parents, and even loved ones is important in music learning.

4. CONCLUSION

In order to get individual and collective insights on learner experiences in the music learning domain, this research applies learning analytics techniques in the music learning domain to define the learners' profiles by continually observing them during their learning process, to identify evidences of both misconceptions and competences, to determine their confidence in reaching the learning objectives, to provide richer insights to learners and instructors, and to track and promote self-regulatory traits of students. MUSIX, as a software agent, proves an effective and efficient complement to the human agent in his/her absence standing by the student to track information about the students' skills, challenges, weaknesses, successes, knowledge, attitude, and study habits and providing the teacher (human agent) with those valuable information even at a distance. The techniques applied in this chapter in MUSIX were also previously applied and experimented successfully in other learning domains such as programming, English writing, and mathematics.

MUSIX is providing teachers with in-depth information about the students' learning status that no traditional music teaching approach is able to provide on a constant basis. Music analytics allows teachers to be aware of the learning process adopted by students in each study session as well as in informal practice time. As discussed in this chapter, the group approach and punctual assessments do not allow to ensure the optimal learning experience for most students. MUSIX focuses on tracking relevant data about the students' daily routine in learning music in order to provide them with an individualized learning path based on the understanding that students' daily study habits is a key factor that affects their level of performance.

MUSIX teaching approach will impact the development of students as they go through instructional sessions, computer-based exercises, games, quizzes, social network interactions, and practice time in assessing what they have learned. In addition, MUSIX offers the ability to students to regulate their own learning habits. Whether it is music theory, vocal training or instrumental playing, MUSIX aims to contribute in the world of music education by tracking students' activities and explicitly capture the growth in music competence and music confidence thus improving the quality of future musicians.

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