Music Learning with Massive Open Online Courses (MOOCs)
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Chapter 2. Learning Music Online

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Abstract. Much of music learning happens outside the classroom in an informal setting, for example online by watching YouTube movies. Despite the many research effort and government projects, many online lack pedagogical foundations while few music educators fully employ online technology yet. In this paper, existing research on online music learning is reviewed as well as platforms and sites that are currently available, mapped in a so-called "market quadrant". Also, the main problems with the current state-of-the-art are identified, along promising technologies that are believed to address these challenges.

Keywords. music learning, online learning, adaptive learning, intelligent tutoring, MOOCs

1. Introduction

It is a running joke among musicians to fret that learning music requires more discipline than joining the army. Mastering an instrument takes upto fifteen years of hard study and truly understanding music is never-ending effort. Even Beethoven took lessons in counterpoint when he was already composing. Maintaining motivation over the long term as well as exquisite personalized feedback are key to success. In principle, online learning thus seems like a perfect candidate to facilitate and increase the intensity of music learning.

Online learning in general is on the rise for more than a decade now [1] and has been found to be at least as effective as traditional teaching [34]. This effectiveness has been mainly attributed to pedagogical aspects rather than the delivery medium itself, however. It appeared that online learning was most effective when the medium and technology was used *comprehensively* in support of learning instead of its usage being a goal on its own. Despite all this, online learning is still in an embryonic phase, evidenced by the fact that most online courses are still reflections of traditional face-to-face teaching. This is a typical pattern in technology adoption in education, where technology is first used to improve what we are already doing (replication), then to do things that we could not do before (innovation), and finally engaging technology to transform content, pedagogy and learning in a fundamental way (transformation). This is even more so for the online learning of music, where adoption is scant and research on the effectiveness is quasi unexisting [52]. At the same time, a lot of groundbreaking

work has already been performed in the field of distance education and pedagogy in general, that could significantly improve online music teaching.

This article surveys the current state-of-the-art in online music learning in an effort to guide teachers and platform designers and argue for the need to bring pedagogy back into the equation. Existing commercial and experimental sites and platforms will be summarized in a so-called *market quadrant*, and current pedagogical issues will be examined. Finally, we will glimpse how future technology might solve some of these issues and provide unique opportunities for scalable online learning.

2. What is already known...

Online learning is a young field that has evolved organically from distance learning, with the internet just offering a new kind of delivery mode. Though a large body of research exists on distance learning, online learning is still relatively underinvestigated. This is particularly the case for learning music online. There have been many research efforts and government projects but, despite the eminence of technology in our everyday's life and educational discussions, in general, music educators do not yet extensively utilize technology directly with students to improve learning [4]. The field has been slow to adapt new technologies due to a combination of skepticism and unfamiliarity [42]. Experiments are set up primarily to test feasibility, with little attention to learning effectiveness and rigorous validation.

It is striking that in times that complete courses and degrees are being offered online, aspects like curriculum design and pedagogy—central to create high-quality learning experiences—are being largely neglected [34] and little research is being done on the effectiveness of these programs [52]. This is even more remarkable given the long, well-documented history of distance learning, dating back more than 200 years [55]. Excellent research has been performed, for example, in the context of Open Universities—such as the work by Rees in summarizing distance learning in music education [42]. For this reason, in the next sections, a brief summary is given of what is known about online teaching. We will focus on three aspects that make online learning unique and different from more traditional forms of teaching: (1) the central role of technology, (2) the distance between teachers and students and (3) the opportunities for (online) collaborative learning.

2.1. Teaching with technology

As the online context increases the complexity of interactions between content, pedagogy and technology, these different aspects can and may not be considered independently: knowing *how to use* technology is not the same thing as knowing *how to teach* with technology [36]. Yet, analysis of existing research has revealed that studies tend to choose technologies, content and learning activities arbitrarily rather than following a theory [34].

Too often, however, online courses are the digital counterparts of traditional face-to-face lectures. This is even more so in the domain of music, where mu-

sic instructors are often unfamiliar with technology or even resistant to it. Yet, "quality online education will be realized only when traditional views of content and pedagogy are reconceptualized within new frameworks that include technology" [49]. Online courses thus need to be designed specifically with the intended delivery platform in mind. Only this way it can be ensured to both make optimal use of the technology at hand at the service of *pedagogical purposes*, and take into consideration the various constraints and specificities of the learning environment [8].

In an effort to create a holistic vision on teaching with technology, the TPACK framework [36] has been devised to include pedagogy, knowledge and technology. Roughly speaking, TPACK is a framework for integrating technology into instruction, arguing for a unified approach in which subject matter and technology are developed in companion. Rather than considering them separate bodies of knowledge, the framework stresses the *complex interaction between them*, needed to create high-quality effective learning experiences. Traditionally, teachers need to both have a deep understanding of the subject matter (content knowledge, CK) and possess the necessary pedagogical knowledge (PK): knowing how to teach, to motivate students, test their skills, scaffold concepts, etc. We believe that for technology to be a useful tool for teaching and learning, teachers should have a good grasp of the technology itself too, as well as how it interacts with content and pedagogy. So far, there has been little interest yet to incorporate these kinds of frameworks into the context of online learning [49].

TPACK has been extended for music instruction by Bauer [4,5]. The music learning activities have been designed to expand an instructor's existing array of practices to include technology—making it an excellent start for teachers who want to increase the use of technology in their music courses. Rather than focusing on the technology itself, the activities attempt to bring attention to the *learning action* students perform when they carry out the activity [19]. Other frameworks can often be adapted or interpreted in the context of online learning too. It would lead us too far to go through all the existing frameworks; we refer to excellent review articles on the topic [33,12].

2.2. Minimizing transactional distance

Another prominent feature of online learning is the *distance* between teachers and students. Already in 1972, M. G. Moore observed that distance was not simply a geographical separation, but a pedagogical concept indicating the *transactional distance*, i.e. the resulting psychological and communicating space that needs to be bridged [38]. In his visionary paper *Learner autonomy: The second dimension of independent learning*, Moore presented an optimistic outlook for distance learning, one in which idiosyncrasy and creativity should be cherished and nurtured for every personality to mature to the level of self-actualisation. According to Moore, three elements are key to determine the extent of transactional distance:

- **structure**
  Structure is needed in order to guide students to acquaint themselves with the different concepts and aspects in a course. Structure includes the course

design, scaffolding strategy, the organisation of learning experiences and the use of various communication media.

- **dialogue**
  Synchronous or asynchronous interaction between teachers and students and students mutually. Though the *medium* of communication is central in the design of dialogue, it is not sufficient. A discussion board, for example, can enable two-way interaction but does not guarantee that it occurs or that it decreases the transactional distance accordingly.
- **learner autonomy**
  Personal involvement of learners drastically improves teaching effectiveness. The expression of the learner's personalities, and time for individual reflection are needed to improve self-regulation. Both meta-cognitive (competence in estimating challenge levels and awareness and monitoring of own capacities) and non-cognitive skills (character, emotions, creativity) are examples of this category.

Often a balance should be found between the different aspects. For example, the amount of content covered should be balanced with the amount of time required for reflection and discussion.

Neuroscientific research supports this viewpoint, indicating that the more ways learners interact with a concept, the more secure it becomes in memory. Furthermore, people tend to learn more efficiently if what they learn is personally meaningful, as well through social interactions. These aspects become even more essential in an online setting where the instructor is not physically present and thus can not actively and continuously gauge the student's interactions and understanding to adapt the teaching style accordingly. All these findings provide support for the four dimensions of transactional distances have been identified in [21], centred around the interactions between:

- learner–content,
- learner–instructor,
- learner–learner, and
- learner–interface.

A similar idea is formulated by the *Community of Inquiry* framework that claims that effective learning occurs in a *community of teachers and students* through the interaction of social, teaching and cognitive *presences*, an identity created through interpersonal communication. A community of inquiry is defined as a group *who collaboratively engages in purposeful discourse and reflection to construct personal meaning and confirm mutual understanding* [17]. Figure 1 shows an overview of the different kinds of interactions.

2.3. Collaborative learning

One of these dimensions, learner/learner interaction, has become particularly popular in the last years with the success of social media and the coming of MOOCs. It is seen as one of the holy grails to solve the scaling problem in MOOCs, together with adaptive learning [58]. This learner/learner kind of learning is often referred to with different names like peer learning, or *collaborative learning*. Exist-

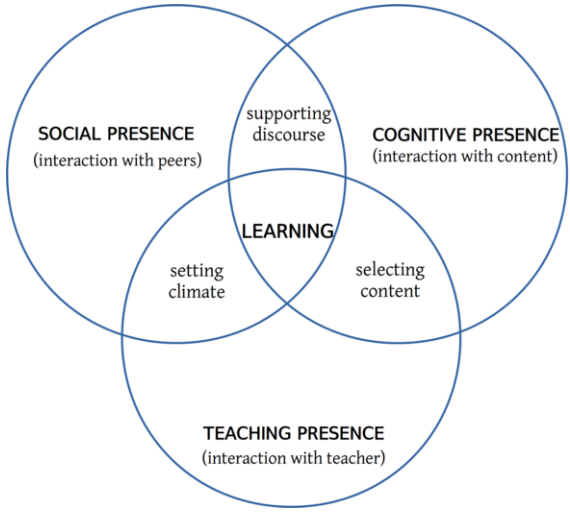

Figure 1. Interactions between different kinds of presences in the community of inquiry framework. Effective learning occurs in a community when social, cognitive and teaching presences interact. In an online setting too, it is important that all interactions are taken care of.

ing definitions of collaborative learning differ significantly and are often vague or subject to interpretation. Roughly speaking, collaborative learning is a situation in which two or more people learn through interactions [15]. This means that collaborative learning can not be reduced to one single mechanism: just like people do not learn because of their individuality, but rather because the activities they perform trigger learning mechanisms, people don't just learn collaboratively because they are together. Rather, it are the interactions between the create activities (explanations, mutual regulations,...) that trigger cognitive learning mechanisms (elicitation, internalisation, ...). For this reason, facilitation and support for these activities should be taken into consideration when designing collaborative learning experiences.

3. What already exists...

Having discussed the main unique pedagogical characteristics of online learning, we will now give an overview of the technological state-of-the-art. Beside collaborative learning, technology is seen as the other promising road towards scalable learning [58] and due to the popularity of Web 2.0, mobile devices and social media, the promise of online learning has become within reach. The nexus of ubiquitous connectivity, cloud computing and intelligent software opens up the opportunity to reduce the transactional distance (1) by boosting the interactivity between learner and content and (2) by providing a virtual "substitute" for the instructor. The following summary will not be limited to formal learning only, as a lot of students' musical achievements occur outside (music) schools. Moreover, with online social networks booming and becoming more pervasive, the borders between formal and informal learning are fading and a lot of musical achievements take place online [44].

3.1. Market quadrant

A quick search on the web will return an abundant amount of sites that claim to "make music learning simple". Clearly, this is only marketing talk as any musician can tell that learning music is a hard process that takes many years, genuine motivation and loads of discipline. Close guidance over the long term to construct a scaffold of personalized learning experiences is thus indispensable. For this reason, two aspects will be covered in deeper detail: the level of *curriculum design* and the level of *personalized learning*.

To gain oversight, the coming overview is mapped out in a so-called "market quadrant", shown in Fig. 2, that maps out every solution with respect to two axes[1]. Curriculum design refers to the extent that the learner is guided through the material, using instructional techniques like scaffolding and indications of what is next. Personalized or Adaptive learning is a term for a collection of techniques—human and computerized—to provide a unique and personalized learning experience, aligned with the goals and needs of each student.

These abstract concepts above have been translated to quantifiable indicators for each axis, based on pedagogical theory. The following components are commonly considered when defining curriculum [26,6]:

(a) *subject matter*: the scope, integration and depth of the material discussed;
(b) *instructional plan*: the strategies of organizing and dividing content;
(c) *horizontal organisation*: the order and continuity of content;
(d) *assessment and evaluation*: the criteria for examining the results.

The indicators listed above and below have been operationalized and have been explained in some more detail in tables 1 and 2 in the Appendix. To measure the level of personalized learning, the following aspects have been used [57]:

(a) *student modelling*, or the ability to represent a student's knowledge;
(b) *expert modelling*, the representation of the expert's knowledge ;
(c) *instructional modelling*, the adaptation of the teaching to the student;
(d) *generativity*, the ability to generate appropriate problems for the student's need;
(e) *mixed initiative*, the interaction with a student to respond usefully; and
(f) *interactive learning*, the learning activities that require real-time student engagement in a domain-relevant and contextualized manner.

When online music technologies are plotted in a graph, we can roughly identify 4 *quadrants*. (a) *instructional sites* with a fixed set of web pages disclosing a particular topic; (b) *games & training tools* that focus on a small particular aspect of music learning; (c) *social media* that empower peer interaction to achieve personalized learning; and finally (d) *blended models*, experimenting with new pedagogies and technologies. A quick glance at the market quadrant in Fig. 2 shows that there is a so-called "scalability" gap that needs to be bridge to achieve true scalable learning online. In the following sections, we will discuss each of these quadrants in more detail. References to each of the different platforms can be found in the Appendix.

[1]The source data of the graph can be found in the Appendix in Tables 3, 4 and 5

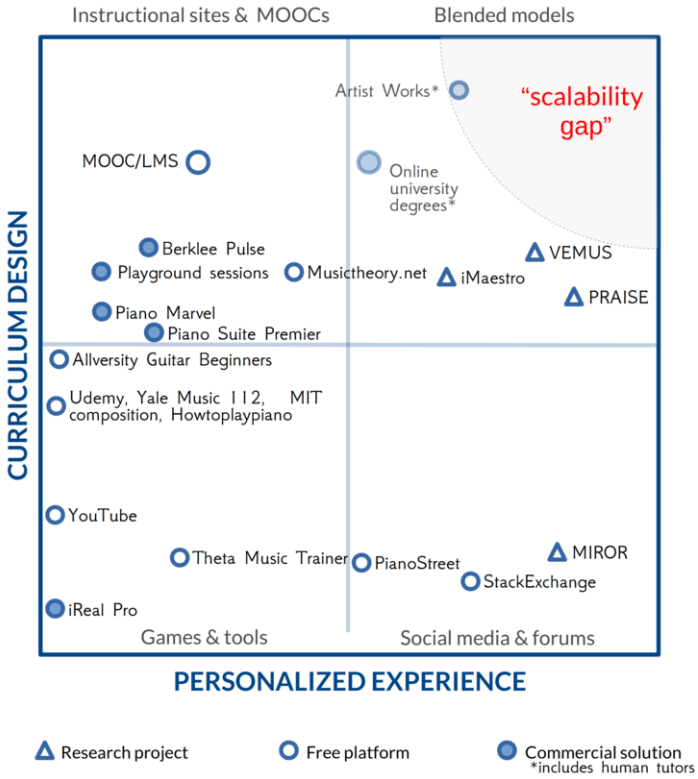

Figure 2. Learning music requires a personalized approach and motivation over a long term (5–15 years). Careful curriculum design and the fostering of personalized experiences is therefore crucial to successful online learning. This market quadrant plots current solutions with respect to these two axes. A "scalability" gap is observed, currently hampering the true potential of online scalable learning.

3.2. Instructional sites

A first category represents the largest share of online music learning resources. Emerged from traditional websites, they consist of typically high quality resources in the form of a combination of text, videos, images and schematics to explain music theory, composition, harmony, etc... Udemy, Yale, MIT, merlot.org and howtoplaypiano.ac are representative examples of this category.

Typically, the content is organized in a fixed curriculum, or a (tagged) collection of independent objects. Online music degrees offered by higher education institutions and delivered through Desire2Learn or other Learning Management Systems, are part of this category as well. Though they offer high quality content, these type of sites often lack the personalised and interactive experience needed for mastering music, especially an instrument. Also, their passive nature is barely inspiring or motivating. The coming of MOOCs like Coursera, however, has opened up new possibilities by combining the advantages of traditional curricula with feedback from peers. Current courses on these platforms, however, show the same shortcomings and lack multi-dimensional assessment.

Nevertheless, some very interesting semi-interactive tutorials exist that carefully explain the basic concepts of music theory, (like Musictheory.net), and in rare cases also advanced topics like Counterpoint or Fugue analysis (Merlot). Proprietary commercial solutions like Berklee Pulse, Piano Marvel, Piano Suite Premier and Playground sessions, offer a more "musical" approach but lack quality feedback, assessment and rigorous curriculum design. Basically they consist of instructional videos, enriched with a song database that allows students to play along.

3.3. Specific games & training tools

A second category consists of interactive games and training tools that promise easy learning of music. Typically they focus on very specific musical problems and thus exhibit very little curriculum design maturity and provide no clue to "what's next". Examples of these tools are: ear training, interval training, playing the right note, tuners, chord finders and playing/singing along. Theta Music Trainer offers an interesting collection of these online tools. Though these tools are designed for entertainment ("fun") and are highly interactive, they consist of disconnected pieces of training lacking scaffolding and offer only superficial feedback like right/wrong, too late/early, ... Though some tools offer a manual setting of difficulty level, these tools are not personalized and lack a pedagogical basis in musical development theory. Their limited scope restricts their effectiveness too.

3.4. Social media and forums

Research has shown that learning can occur through shared activities performed in participatory communities of practice [53]. Self-directed learners that are in control of their learning, can construct environments to support their learning (for example in social networks). Equivalent processes in the real world of music are garage bands, choirs and orchestras. A reflection in the online atmosphere makes up the third and relatively new phenomenon in music learning, the emergence of social media or networks. Too often, however, these online activities are seen as asocial by traditional educators [46], probably because this idea is at odds with traditional view on (music) education that focuses on the transfer of factual and established knowledge from a central authority.

Examples of platforms on which musicians can ask specific questions are Stack Exchange and PianoStreet. Though these Question and Answering platforms offer highly personalized and collaborative feedback and interaction, the ad hoc "requirement-based" approach offers little guidance and combined with the small scope of questions, again limits their effectiveness for music learning in the long term. Still, the impact of general platforms like YouTube, Facebook and Soundcloud should not be underestimated in informal settings, creating communities of musicians that share music, get feedback on compositions and engage in discussions.

3.5. Blended models

The last kind of platforms, *blended models*, finally, contains sites that try to combine a rigorous curriculum with personalized learning. Three main techniques can be discriminated. The first blends learning settings and human-assisted tutoring with curriculum design. Online university degrees are good examples in which a purely online degree is enhanced by feedback from human experts through synchronous or asynchronous feedback. Another example is the solution from *Artist Works*, in which students and human tutors communicate by uploading video of their playing and get feedback through another video. This way, students receive personalized feedback from experts, who are also in charge of mapping out the curriculum. Clearly, this solution does not scale.

A second approach attempts to improve personalized learning by putting peer learning and communities at the core of traditional instructional sites like MOOCs. The discussion boards are no longer secondary to the learning material, but central to the learning experience. cMOOCs are manifestations of this category. A similar approach is taken in PRAISE, a European FP7 project. PRAISE (Practice and peRformance Analysis Inspiring Social Education) focuses on collaborative online processes and aims to analyse the nature of feedback that characterize those processes [47].

Recently, *adaptive learning* is hoped to replace some tasks of a human (expert/peer) tutor by intelligently designed pieces of software that guide students through the learning process; this is done by selecting appropriate learning activities and providing interactive tutoring and sensible feedback. The Virtual European Music School's (VEMUS) is such an example. It tries to pave the way to an open interactive platform [11] by integrating a whole range of technology, connected to music learning: interactive on-line and off-line collaboration "music rooms", automated audio analyses, score editing tools etc.. The iMaestro project [23] took a more technological approach and has focused on creating tools and methods for courseware production and to host interactive, collaborative and creative rehearsals, incorporating multi-modal interfaces and new kinds of visualizations. Both have a very technological focus and lack in-depth, intelligent and musical feedback, however.

A last research effort is worth mentioning, as it takes a fundamentally different approach to music learning. The MIROR project is based on so-called "reflexive pedagogy" [35] or the idea that children can learn how to play music by listening to virtual copies of themselves. Specific machine learning software have been developed, called *Interactive Reflexive Musical Systems* (IRMS). The system acts as a tutor, designed to interact with learners in the field of music improvisation. Several artificial intelligence and multi-modal signal processing techniques were employed to create an inspiring environment that fosters creativity. The evidence on learning effectiveness remains meagre, though.

4. What the problems are...

So far, we have outlined the existing pedagogical knowledge on online learning, as well as the state-of-the-art in educational technology for music learning. As

mentioned before, there are, however, still many challenges that the platforms above are facing. In the next sections, we will dig deeper into these issues.

4.1. Limited body of research

Despite the large body of research on *traditional* music pedagogy, most of the current platforms lack a rigorous pedagogical basis and are primarily inspired on a behaviourist / transmission model view on education. Existing solutions are typically constructed in an ad-hoc fashion and lack systematic testing based on theory [34]. Even worse, there is very little scientific evidence on the effectiveness of these programs at all.

Although growing, the amount of research on *online* music learning is still very limited [8], and the studies that do exist are typically small in scope: they consider a small number of students (10-30) and experiments last a short period of time only (few weeks to few months). Furthermore, most online degrees deal primarily with academically oriented courses like music theory or history, not the teaching of manual skills [41]. For example, the different pedagogical functions of synchronous vs. asynchronous communication have been largely uncovered, even though existing research has shown that asynchronous communication when assessing or discussing music performance has been shown feasible and functional but less effective than synchronous face-to-face interaction [14]. As music is intrinsically multi-modal, more research is desperately needed for reliable multi-modal interfaces and feedback, even though technology is improving.

Finally, as a lot of these studies have been carried out by technicians and computer scientists, they typically focus on technology and delivery mode, neglecting pedagogical aspects and missing the crux of how the new technologies can be put to effective use [8].

4.2. Lack of quality assurance

Second, for online learning in general, a lot of critical voices are heard from professors in universities and colleges, afraid that "cheap MOOCs" with underperforming pedagogical foundations will replace faculties, warning of the misleading promise from MOOCs to improve education [37]. Exactly the opposite reasoning is heard too, however: that MOOCs may as well *improve* the quality of courses globally, as locally organized courses can no longer afford to be of a lower standard than an online course [2].

From the moment that universities or other institutions like governments are starting to provide certificates of equal value to online courses, the *credibility of assessment* becomes critical [10,18]. There are still, however, some compelling challenges like cheating or scaling to overcome [51]. Research into peer and self-assessment look promising and seems to work well when the students level is homogeneous, when students have a similar model of perception of "quality" and if they are properly trained in grading. Furthermore, evidence seem to indicate that students *learn* from these kinds of grading [45]. Still, assessments are in an early stage of development, testing for skills only superficially and not yet in a trustworthy way.

Furthermore, as mentioned before, very little attention is paid to assessment of the *learning effectiveness* of existing degrees and platforms. A study by Harvard in the context of MOOCs, revealed that students "emphasized the continuing importance of in-person discussion sessions" [20], as contact and dialogue between tutors and students is still considered key to teaching [29,54]. This necessity of human tutors makes some people fear that MOOCs will in the end not keep up to their promise, because maintaining the staff-to-student ratio of roughly 1:25 needed to counsel students will mean that even MOOCs will not scale. For this reason, Laurillard concludes that "education is not a mass customer industry: it is a personal client industry" [31].

4.3. Little personalized learning

The current standardized nature of online degrees and platforms, lacking personalized instructional guidance, thus makes current MOOCs suboptimal platforms. With the exception of some highly self-motivated and disciplined students, the lack of supervision and guidance hinders effective learning [39]. Also, current courses do not take into account personal differences in learning goals and ambitions, their background or the pace of learning. Especially with a diverse audience as in MOOCs, these factors are crucial for success [3]. In addition, learning material is typically presented in a linear "transmission model" fashion—not effectively exploiting pedagogies and other technologies suited for the online realm, such as those rooted in artificial intelligence like student modelling, gamification, intelligent tutoring systems and simulation.

5. ...and how technology can help

One of the main reasons why the huge potential of online courses is not exploited, is the tendency to think in terms of classical course-room lectures. The most interesting experiments have thus emerged by challenging the status quo by loosening the rigid control of learning outcomes and assessment criteria, shifting from content delivery to a learning process, experimenting with alternative assessment methods, games, and so forth [29]. Despite all the promises and expectations, the effects of computer aided instruction and virtual learning environments on learning have been rather disappointing till now.

The ultimate question is whether collaborative learning and novel intelligent software will be able to bridge the "scalability gap" illustrated in 2, delivering a personalized learning experience and a rigorous curriculum to the masses. The omnipresence and advancement of information technology and the hype for MOOCs may have created a new momentum for online learning. Indeed, web technology has advanced to the stage that complex applications can run in the browser (e.g. Office 365), while digital devices and social networks like Facebook have become an integral part of our lives. Multi-modal interfaces like sound, video, or motion capture are becoming ever more sophisticated and open unique opportunities to provide a rich interaction with the user. In the following sections, we will elaborate on the unique opportunities that the current technological advances with a global leverage might bring.

5.1. Educational Data Mining

A first interesting evolution is the emergence of a field called "Educational Data Mining" (EDM), that should be seen in the larger trend towards digitalization of education [56]. EDM aims to apply data mining techniques in order to better understand learning. Its applications range from analysis and visualization of data, providing feedback to instructors and course designers (when do students login, what topics do they visit the most, what patterns can be identified), making recommendations to students (for example of related content to explore), predicting student performance, student modelling, learning analytics and much more [43]. LearnSphere, an online database aimed at collecting information on learning, is another shot at consolidating the knowledge on learning and unlocking its potential to create better online courses [32]. Similarly, data scientists will have a seat at the table when designing courses, for example, to translate learning hypotheses into measurable quantities [28]. Studies start to arise that empower MOOC platforms to gauge the knowledge and competences of students and their capacity to learn [16].

5.2. Adaptive learning / intelligent tutoring

Another obvious shortcoming in music learning online, are personalized curricula that go beyond fixed-content delivery, difficulty levels (beginner/medium/advanced), or very small-scope training tools. Domain models, as investigated in artificial intelligence's intelligent tutoring systems or recommender systems, should be constructed for the domain of music. Strangely enough, students have mainly remained out of the picture in existing online platforms. Keeping track of student's curriculum, emotions, practice schedule and their musical knowledge through student modelling is an absolute necessity. Feedback, tailored to the specific learning goals and problems a student encounters (diagnostics and repairs), could drastically improve the learner's experience [7]. Furthermore, the commonly used behaviourist approaches are not particularly well suited to foster creativity and critical thinking. Yet, creativity—diminishing since the '60s [30]—is considered as the most crucial factor for future success and innovation, according to a survey of IBM [22]. Though teamwork and collaboration can stimulate creativity [25], more attention should be paid; for example, using exploratory interactive learning environments.

5.3. Personalized feedback

Automated feedback provided by existing interactive learning environments currently lacks musicality. Knowing that a note is too early or late does not provide the necessary means to correct this situation. Furthermore, offering real help in the sense of providing learning strategies to improve is essential to speed up learning and make it inspiring. In addition, the automatically generated feedback on performances is highly unidimensional and lacks qualitative components that are crucial in learning music: rather than indicating wrong/right or note too early/too late, repair mechanisms should be suggested to improve their practice.

For beginning students, this kind of interaction does not motivate nor help them to advance. Also, instructional techniques like scaffolding are not employed.

One option that is seen as the "holy grail" of online education is to employ intelligent tutoring systems to guide students through the learning experience and provide them individualized sensible feedback. These systems should be designed to keep users in *flow* by presenting them challenges and experiences that match their capabilities at any time, prevent boredom or anxiety and optimize learning [13,48].

5.4. Gamification

A last promising approach to online learning is gamification. Teachers have been using games for ages in their classes: a recent survey unveils that 73% of the teachers in the USA use games at least once a week [24]. Gamification and "serious games"—the use of concepts and techniques from games outside the entertainment business—are currently explored [40]. One recent example is the MineCraftEDU project, reaching about 250,000 students [50], where pupils can learn about history in a virtual world representing ancient societies, meet famous historical figures, embark on quests to learn about these fascinating cultures, explore genetics in real-time interactively [27], simulate social conflicts, or get insight into the spread of epidemics through a simulator game [9].

6. Conclusions

Learning music is slowly moving into the digital and online atmosphere. Interesting opportunities lie ahead, with the coming of multi-modal interfaces and global communities of learners. The advancements in artificial intelligence may provide personalized automated learning experiences, employing intelligent tutors and gamification techniques, while the field of educational data mining and learning analytics may provide key insight into how people learn, finally.

However, there are still some issues that need to be addressed to bridge the "scalability gap". First, creators of online courses should focus more on pedagogy and on how to teach with technology, reusing the large body of knowledge that has been constructed in the domain of distance learning. Second, further pedagogical study is needed about the techniques required for teaching manual skills using new interfaces. Lastly, more research is needed to assess and investigate the effectiveness of online learning platforms. For the domain of music specifically, more experimentation is needed to investigate efficient modes of synchronous and asynchronous communication—for performance practice and music learning in general.

A. Indicators & data

Aspect	Indicator
Subject matter	
scope	Number of handled subjects [2]
integration	Are the educational objects organized using tags or categories?
	Are their dependencies between educational objects?
Instructional plan	
scaffolding	Are learning tasks organized according to difficulty?
	Are tasks organized conforming a logical structuring of content?
Horizontal organization	
continuity	Is the learner guided through the subject matter?
sequence	Is there a strategy behind the *sequence* of learning tasks?
Assessment	
tests	Is there some form of assessment?
	Are the tests more sophisticated than multiple-choice?

Table 1. Criteria of maturity of Curriculum Design. Every studied software, site or platform is scored on each of these categories.

Aspect	Indicator
Student modelling	
skill level	Is the knowledge of the topic being tracked?
goals	Can the learning be customized?
Expert modelling	
domain model	Is there a model of the domain knowledge?
Mixed initiative – Interactive learning – generativity	
feedback	Does the feedback provide insight?
	Is qualitative feedback given? (typically by humans)
exercises	Can new exercises be generated?
game play	Are there games in which real-time interaction is required?
just-in-time	Is information given on the right time, situated an on-demand?
Instructional modelling	
skill level	Is the skill level adapted to the student's need?
repairs	Are problems diagnosed and repaired?

Table 2. Criteria of Adaptive or Personalized Learning, from literature on Intelligent Tutoring Systems.

Platform	URL	Type	X-score	Y-score
Coursera	https://www.coursera.org/	F	1.88	1.71
Musictheory.net	http://musictheory.net	F	2.19	2.82
Allversity Guitar Beginners	http://www.allversity.org/courses/beginners-guitar	F	0.50	3.49
StackExchange	http://music.stackexchange.com/	F	4.50	5.71
YouTube	http://www.youtube.com	F	0.50	5.04
Theta Music Trainer	http://trainer.thetamusic.com/	F	1.73	5.49
Udemy "Learn free music theory"	https://www.udemy.com/learn-free-music-theory/#/	F	0.50	3.93
Howtoplaypiano.ca	http://howtoplaypiano.ca/	F	0.50	3.71
Music 101: Intro to Music	http://education-portal.com/academy/course/	F	0.50	3.27
BBC Sing	http://www.bbc.co.uk/sing/learning/	F	0.50	4.38
Yale "Music 112: Listening to music"	http://oyc.yale.edu/music/musi-112	F	0.50	3.49
MIT Introduction to Music Composition	http://ocw.mit.edu/courses/music-and-theater-arts/	F	0.50	3.49
Online music theory tutor	http://www.childrensmusicworkshop.com/musictheory/	F	1.73	3.71
PianoStreet	http://www.pianostreet.com/	F	3.42	5.71
iReal Pro	http://irealpro.com/	C	0.50	6.16
Piano Suite Premier	http://www.adventus.com/store/piano-suite-premier/	C	1.42	3.27
Piano Marvel	http://www.pianomarvel.com/take-a-tour	C	0.96	3.04
Artist Works Music & Arts campus	http://artistworks.com/	C	4.65	1.27
Playground sessions	http://www.playgroundsessions.com/	C	0.96	2.82
Berklee Pulse	http://www.berkleepulse.net/	C	1.42	2.60
MIROR	http://www.mirorproject.eu/	R	5.27	6.16
PRAISE	http://www.iiia.csic.es/praise/	R	6.04	3.04
VEMUS	http://www.tehne.ro/projects/vemus_virtual_music_school.html	R	4.96	2.60
iMaestro	http://www.i-maestro.org/	R	4.19	2.82

Table 3. Overview of aggregated scores for each platform.

Platform	depth	object tags-cats	depend. ob-jects	diffi-culty orga-niza-tion	con-tent orga-niza-tion	fixed guide-through	se-quence strat-egy	assess-ment?	multi-ple-choice	stu-dent model	goals
Coursera	3	0	0	0	1	1	0	1	1	0	0
Playground sessions	2	0	0	1	1	1	0	1	0	0	0
Berklee Pulse	2	0	1	1	1	1	0	1	0	0	0
Musictheory.net	3	0	0	0	1	1	0	1	0	0	0
Allversity Guitar Beginners	3	0	0	0	1	1	0	0	0	0	0
PRAISE	1	1	0	0	1	1	1	0	0	1	1
VEMUS	2	1	0	0	1	0	0	1	1	1	0
iMaestro	2	0	0	0	1	0	0	1	1	1	0
StackExchange	1	1	1	0	0	0	0	0	0	0	1
YouTube	3	0	1	0	0	0	0	0	0	0	0
iReal Pro	1	0	0	0	0	0	0	0	0	0	0
Theta Music Trainer	0	0	0	1	0	0	0	1	0	0	0
Udemy "Learn free music theory"	2	0	0	0	1	1	0	0	0	0	0
Howtoplaypiano.ca	1	0	0	0	1	1	0	1	0	0	0
Music 101: Intro to Music	2	0	0	0	1	1	0	1	0	0	0
BBC Sing	1	0	0	0	1	1	0	0	0	0	0
Yale "Music 112: Listening to music"	3	0	0	0	1	1	0	0	0	0	0
MIT Introduction to Music Composition	3	0	0	0	1	1	0	0	0	0	0
Online music theory tutor	1	0	0	0	1	1	0	1	0	0	0
MIROR	1	0	0	0	0	0	0	0	0	1	1
Piano Suite Premier	2	0	0	0	1	1	0	1	0	0	0
Piano Marvel	2	0	1	0	1	1	0	1	0	0	0
Artist Works Music & Arts campus	3	0	0	1	1	1	1	1	0	1	0
PianoStreet	2	0	0	0	0	0	0	0	0	0	0

Table 4. Overview of indicator scores for curriculum design for each platform.

Platform	Domain model	Feedback insight	Qualitat. feedb	Gener. exerc	Game / play	Info on time	Adapted skill level	Diag & repairs (exercises)
Coursera	0	0	1	0	0	1	0	0
Playground sessions	0	0	0	0	1	1	0	0
Berklee Pulse	0	0	0	1	1	1	0	0
Musictheory.net	0	0	0	1	1	1	1	0
Allversity Guitar Beginners	0	0	0	0	0	0	0	0
PRAISE	1	1	1	0	0	1	0	0
VEMUS	1	1	0	1	0	1	1	0
iMaestro	0	1	1	1	1	1	0	0
StackExchange	0	1	1	0	0	1	1	0
YouTube	0	0	0	0	0	0	0	0
iReal Pro	0	0	0	0	0	0	0	0
Theta Music Trainer	0	0	0	0	1	1	1	0
Udemy "Learn free music theory"	0	0	0	0	0	0	0	0
Howtoplaypiano.ca	0	0	0	0	0	0	0	0
Music 101: Intro to Music	0	0	0	0	0	0	0	0
BBC Sing	0	0	0	0	0	0	0	0
Yale "Music 112"	0	0	0	0	0	0	0	0
MIT Music Composition	0	0	0	0	0	0	0	0
Online music theory tutor	0	0	0	0	1	1	1	0
MIROR	0	0	1	1	1	1	1	0
Piano Suite Premier	0	0	0	1	1	1	0	0
Piano Marvel	0	0	0	0	1	1	0	0
Artist Works Music	0	1	1	0	0	0	0	1
PianoStreet	0	1	1	0	0	1	1	0

Table 5. Overview of indicator scores for personalized learning.

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