An active e-book to foster self-regulation in music education

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Abstract
Purpose – The purpose of this work is to analyze the concept of self-regulated learning and applying it to a web-based interface for music teaching.

Design/methodology/approach – This work starts from a systematic review about music education and self-regulation during learning processes. Then, the paper identifies those meta-cognitive strategies that music students should adopt during their instrumental practice. The goal is applying such concepts to rethink the structure of a didactic e-book for instrumental music education. Thanks to the adoption of the Institute of Electrical and Electronics Engineers (IEEE) 1599 standard, the paper outlines a model of active e-book able to improve learners' performances through proper cognitive and multi-modal scaffolds. In the last section, the design principles for an implementation will be proposed.

Findings – This work applies theoretical research on self-regulated learning to the design and implementation of a working prototype.

Research limitations/implications – A limitation is the lack of experimentation data, required to test the efficacy and effectiveness of the proposed e-book model and its impact on self-regulated music abilities. A validation strategy – e.g. based on scenarios – will be proposed in our future works, thanks to the support of music learning centres and focus groups composed by young Italian students.

Originality/value – This work has been invited as an extension of the paper presented by the authors at EL2014 International Conference held in Lisbon. The previous work has been awarded as the best paper of the conference. In this extension, the authors provide further details about the proposed framework, highlighting in particular the implementation of scaffolds in the interface.

Keywords Multimedia, E-Learning, Active e-book, IEEE 1599, Music education, Self regulation

Paper type Research paper

1. Introduction
Music education for the young, particularly during *early childhood* (between the ages 3 and 8) requires a specific review of course curricula. An integration of multi-modal experiences based on activities such as moving, creating, playing and reflecting (Young, 2003) is required to train a *symbolically fluent child* (Jorgensen, 2002; Barrett, 2009).

The learning environment should be able to represent activity-oriented musical experiences, where students, properly sustained by scaffold elements, are involved in a process of music construction/deconstruction. For example, according to (Tomlinson, 2013), expanding or scaffolding children's early musical experiences and investigations, their engagement in the world of sound, their trans-modal redesign of known literature

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and song repertoire to communicate new meanings helps children establish strong, confident, vibrant and creative identities in learning, communication and performance.

Recent research results emphasized the importance of seeing and hearing children's perspectives to embed children's voices within curricular choices (Griffin, 2009). The path to the music knowledge for young people requires a redefinition to allow them to influence and actively build the course of their studies, namely, to negotiate their own pathways by remaking texts. An active interaction in education should engage learning processes for children through complex, authentic communication (Kress, 2004).

Children negotiate their own identities and pathways by remaking interactive texts and representations, catching in this way, the essence of the alterations, transformations, musical arrangements and practices (Kress, 2013).

New digital technologies allow to imagine new ways to design and implement educational text, as well as new interaction possibilities. Traditional publications should be reviewed to make them usable from different perspectives and along different pathways. In particular, a guided content customization should be provided. Nowadays, the exploration-driven learning environments are particularly relevant for music theory and musical instrument teaching. These frameworks emphasize key ideas such as an interactive and progressive investigation, and the development of an intuitive and creative way of thinking, as reported in (Jorgensen, 2002).

These supports, if properly conceived and redefined, could endorse self-regulatory cognitive and meta-cognitive strategies. Unfortunately, e-books today have a linear structure with a single path through content, and the lack of choice reduces the possibility to control the learning experience. For the new generation, the innovative e-book has to be flexible, adaptive and dynamic in the order and way in which content is studied.

2. Self-regulation and music education

Education technology, i.e. the research field that investigates how to teach and learn through media, denotes the self-regulation capability as a crucial element to be considered when defining a learning environment (Chang, 2005). As stated in (Järvelä and Järvenoja, 2011 and Zimmerman, 2008), self-regulation is fundamental for a successful learning process because it helps students to create their own "method" and strengthen their study skills (Wolters *et al.*, 2011), to apply the best strategies to reach their educational goals, to control their performance and to evaluate their academic progress (de Bruin *et al.*, 2011).

Learning, particularly when related to *conceptually rich domains* (Azevedo, 2005; McMahon and Oliver, 2001; Lin, 2001), requires environments which support activities of self-regulation, controllable and revisable also in a participatory way (Schunk, 2008). Recent works, such as (Schunk and Zimmerman, 2007; Graham and Harris, 2000 and Kistner *et al.*, 2010), demonstrated that self-regulated students obtain better results as regards both motor and conceptual performances. Staring at teaching and learning from the self-regulation perspective has great potential in music education, and in instrumental didactics in particular.

Practising a musical instrument presents many challenges. For instance, students are required to practice over a long period of time, to focus on their goal, to face the threats typical of a competitive learning environment, to gather feedbacks to improve their performance, to overcome insecurity, to develop a psychological and behavioural toolkit against pressure and problems (Martin, 2008).

Music education experiences a high drop-out rate caused by students' sense of failure. Works such as (McPherson and Renwick, 2001) and (Pitts and Davidson, 2000) show that young music students are not methodical in their learning process. Like any other theoretical or practical discipline, music learning requires a good self-regulation attitude. Most indications come from a longitudinal research that investigated the evolution of 157 children practising a musical instrument between the ages 7 and 20 (McPherson and Renwick, 2001). Research results highlight the importance of self-regulation theory as a tool to support music knowledge and skill acquisition.

To gain ability to play a music instrument, the young student has to learn and apply a number of behaviours aiming at improving his/her own performances, such as: managing and planning exercise activity, promptly reacting to his/her performance or to external feedbacks (e.g. when practising in an ensemble), modifying and adapting strategies, adequately setting the environment and asking for help when needed to access useful resources for learning.

Music mastering occurs when *ad hoc* scaffolds are provided to the learner, helping him/her to adopt self-regulated mechanisms to monitor and control performances (McPherson and Zimmerman, 2011).

With respect to other research areas about learning, only now the one related to instrumental practice is beginning to consider and apply the *self-enhancing cycle*, a key concept of the self-regulation learning theory. About self-regulation techniques, young music students can adopt the model by Zimmerman and Campillo (2003) has been recently applied to the self-regulated problem-solving process. Three cyclical macro-phases are identified (McPherson and Renwick, 2001), as shown in Figure 1. A detailed analysis of self-regulation cycle is fundamental to identify the proper scaffolds for active music e-books, as discussed in Section 6.

2.1 Forethought

This phase is based on *task analysis* (goal setting and strategic planning) and *management of self-motivation beliefs* (self-efficacy, outcome expectation and intrinsic motivation) (McPherson, 2005). By autonomously defining medium- and long-term goals, students can fix their own performance standards and become more motivated. Self-confident students are more effective in their learning efforts and do not give up when they have to face difficulties. Young musicians have to apply strategic learning

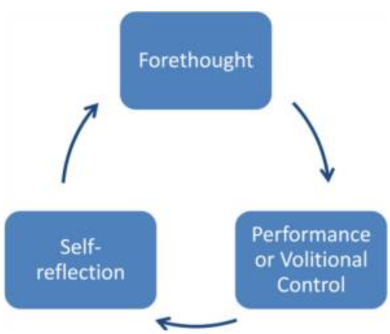


Figure 1. Cyclical phases of self-regulation

behaviours (strategic planning) by identifying the most appropriate methods to accomplish a given task, without losing sight of the defined goals. An example of strategic planning for a musician is to stop performing warm up material from the printed score, and start playing the memorized text. Other strategies include hand annotations written on the score, or well-known techniques of *sight reading* (McPherson and Renwick, 2001).

The idea of self-efficacy is fundamental for a musician (Bandura *et al.*, 1999), and it implies the self-recognition of being a good instrumentalist. This opinion interacts with the outcome expectations (Graabraek Nielsen, 2008), thus affecting the continuation of musical studies. Self-efficacy drives students to evaluate their performance not only on the basis of external rewards but also for the intrinsic motivation of personal satisfaction (Zimmerman, 2002).

2.2 Performance or volitional control

We can recognize two processes that students can apply to improve their performance:

(1) *self-control* (self-instruction, imagery, attention focusing); and

(2) *self-observation* (self-recording and self-experimentation).

Self-control processes help musicians to concentrate on their musical performance and to optimize efforts. For instance, they can adopt *self-tasks* to learn a difficult section during instrumental practice. This kind of self-instruction let students monitor their concentration during learning activities (Vygotsky, 1962). Other examples are: *inner self-speech*, also known as *positive self-talk* (e.g. "I can do this!") that increases the focus on performance and alleviates performance anxiety; the creation of *mental blueprints* about specific goals; breaking up the whole piece into smaller sections, are easier to be studied (Miksza, 2007).

Self-observation highlights progresses – or their lack – in performance skills and instrumental techniques. In Lehmann and Ericsson (1997) the process has been decomposed into three kinds of representation:

(1) An *aural representation* of the target performance (i.e. how the piece should be played).

(2) A *motor representation* of the physical actions required.

(3) Finally the *representation of current performance*, constantly monitored and compared to the performance of reference the musician has in mind.

Feedbacks act as cues prompts by suggesting to young students how to improve their performance. A clarifying example is switching from the interpretation of graphical symbols for crescendo and diminuendo to an *inward feel* about music expression.

2.3 Self-reflection

The third phase of the self-regulated learning cycle is based on *self-evaluation*, *causal attribution*, *self-satisfaction/affect* and *adaptivity* (Zimmerman and Campillo, 2003). Self-evaluation is one of the initial processes of self-reflection, and it implies a comparison between personal performance on one side and performance of peers on the other. The latter is considered either a standard to satisfy or a goal to achieve. Self-regulated musicians typically attribute their success to causes that can be improved only through a greater effort. Adaptive inferences will lead to reflect on the best learning strategy, while defensive inferences will tend to limit the personal commitment and will lead to the abandonment of the activity. A high self-satisfaction level will push students towards new goals and challenges.

3. Towards active e-book for self-regulated learning

The idea of making a school subject more engaging through computer-based technologies is not new at all. An example is the adoption of interactive blackboards in primary and secondary education to add multimedia and interactive contents to "traditional" ones. For instance, (Sunners *et al.*, 1994) describes a framework that integrates the blackboard model with a graphical user interface, and (Van Zeir *et al.*, 1998) provides an extensive overview of the data models and the knowledge sources that form the back-bone of an interactive computer-aided process planning kernel. In the field of music education, this approach is particularly relevant, as the subject is strictly related to multimedia and multi-modal interfaces. In fact, e-books for music education have been already designed and released. Unfortunately, their typical approach provides a linear pathway through contents and allows a low degree of interaction: in other words, they are usually digital copies of traditional paper texts. Needless to say, digital technologies can introduce some aspects of novelty peculiar to music:

- Hyper-links can easily provide further information about an instrument, an author, a music genre, etc.
- Scores can have a performance associated with, so that the learner can listen to a pre-recorded performance by either a professional player or an automated system.
- Music notation can be presented in alternate formats, designed for visually impaired students or people affected by learning disabilities.

However, music e-books available on the marketplace are far from the definition of "active book" mentioned in Section 1. The *study mode* proposed by an active book is different from the *reading mode*, where the learner is able to freely read any part of a text, and solve any task or interactive part without any restriction. Rather, the model is characterized by the fact that the progress of reading (in this case studying) is handled by the textbook itself (Binas *et al.*, 2012). In this approach, there are many concurrent study paths related to the goals and levels of detail of a given subject. Any chapter, activity, exercise proposed to the learner is related to a previous path made of actions that can be seen as prerequisites.

In the *study mode*, different paths are offered to access contents by skill degree, personal interest and goals to achieve. Contents are structured to provide guidance to learners, keeping the didactic framework supervised and designed to achieve the best results.

Digital active books should let students adjust their cognitive and meta-cognitive behaviours (Aleven *et al.*, 2010; Azevedo *et al.*, 2005; Winne, 2011) thanks to appropriate scaffolds (e.g. *feedbacks* and *prompts*). As stated in (Aleven and Koedinger, 2002) and (Graesser *et al.*, 2000), scaffolds are functional to the development of specific self-regulation skills in the music field. For this reason, in Section 6, the subject will be discussed in depth.

In scientific literature, many different theories and visions are present about scaffolding. This heterogeneity resulted in a number of adaptive approaches and assistive technology solutions, often united by the concept of fixed and adaptive scaffolds (Azevedo *et al.*, 2005). Researchers have stressed how adaptive scaffolding in hypermedia environments can assist students in developing more sophisticated mental models, increasing declarative knowledge as well as the frequency of some self-regulated learning strategies (Azevedo and Hadwin, 2005). The mentioned studies have inspired the design and development of innovative learning systems employing the adaptive component in didactic self-regulation.

Further studies (Kramarski and Hirsch, 2003) have provided empirical evidence that an adaptive scaffolding – based on *feedbacks* and *prompts* – when applied to scientific subjects supports the execution of regulation strategies. The importance of *cueing* and *prompting* has been confirmed by the work of (Azevedo *et al.*, 2005), thus paving the way for new studies on adaptive scaffolding as a key element in the education of self-regulated learners.

Nowadays, the scientific community is paying a great attention to the effectiveness of different kinds of scaffold on students' self-regulation processes (Lajoie, 2005; Hadwin and Winne, 2001; Baylor, 2002; Puntambekar *et al.*, 2003). Research results are used to revise the design of adaptive hypermedia learning environments.

4. Technologies for an active music e-book

At the moment of writing, HTML5 is the latest release of HyperText Markup Language (HTML), specially designed to display rich content without the need for additional plugins. It can deliver a heterogeneous set of media contents, ranging from animation to graphics, from music to videos, etc. It can be used to build complicated and rich web applications, too.

HTML5 is a cross-platform because it has been designed to work on personal computers, tablets, smartphones, e-book readers and other technological devices such as smart TVs. Virtually, any device equipped with a HTML5-compatible browser supports HTML5 applications. Thanks to its features, HTML5 is revolutionizing not only the web but also many other fields.

With the release of the EPUB 3 specification (Garrish, 2011), HTML5 is officially a part of the EPUB standard. Consequently, publishers are able to take full advantage of its set of features to add rich media and interactivity to their e-book contents. The integration of HTML5 into e-book readers allows a number of advanced and innovative applications, such as the support of audio/video, the use of geolocation to customize a work of fiction, the creation of colouring books, etc. Some relevant examples are described in (Kleinfeld, 2011 and Choi *et al.*, 2014).

Nevertheless, some features oriented to music education and instrumental practice may require a more specific format, able to represent heterogeneous music contents on one side and on the other side compatible with HTML technology. This format could be Institute of Electrical and Electronics Engineers (IEEE) 1599 (Baggi and Haus, 2009), an international standard aiming at a comprehensive description of music contents that has been approved by the IEEE Computer Society in 2008. IEEE 1599 adopts Extensible Markup Language (XML) to describe a music piece in all its aspects. XML is a simple, but very flexible text format which is playing an increasingly important role in the exchange and publishing of a wide variety of data on the web and elsewhere. Because XML is one of the standards recognized by the World Wide Web Consortium

(W3C), the choice of integrating IEEE 1599 into an e-book is coherent, as demonstrated in Sections 5 and 6.

With respect to other music formats, the innovative contribution of this standard is providing a comprehensive description of music and music-related materials within a unique framework, ranging from symbolic score to catalogue metadata, from score images to audio tracks. Comprehensiveness is realized through a multi-layer environment where data are arranged within six layers, each corresponding to a different information type. In IEEE 1599, these layers are called: general, logic, structural, notational, computer-driven performance and audio.

A complete description of the format goes beyond the goals of this work. For the sake of clarity, it is sufficient to say that the music events in a piece are univocally identified through a common data structure, and all layers can refer to them through such IDs. Thanks to this concept, IEEE 1599 supports two synchronization modes:

(1) *Inter-layer synchronization*, which takes place among many descriptions of the same music event in different layers. For example, the notational layer (score) and the audio layer (performance) provide descriptions belonging to different domains, but linked together by shared event IDs. This feature can be used to implement a score following software, where the synchronization among graphical and audio contents can be retrieved from the XML document itself.

(2) *Intra-layer synchronization*, which occurs among multiple instances of the same music event within a single layer. For instance, two audio performances of the same piece can be synchronized event-by-event. In fact, it is sufficient to mark the occurrence of the same notes inside the two materials, by associating the common ID of each note to its different timings.

An in-depth description of the key aspects of the standard is provided by Ludovico (2013). For further details, please refer to the official IEEE repository. Finally, it is worth citing the EMIPIU portal[1], where an HTML5 viewer for IEEE 1599 documents is publicly available.

5. A case study of active book for music teaching

The idea of adopting innovative technologies to foster music learning and improve music teaching experience is not new. Many music textbooks equipped with digital supports are already available on the marketplace, and the attached contents represent interesting attempts to foster learning and interaction with music contents.

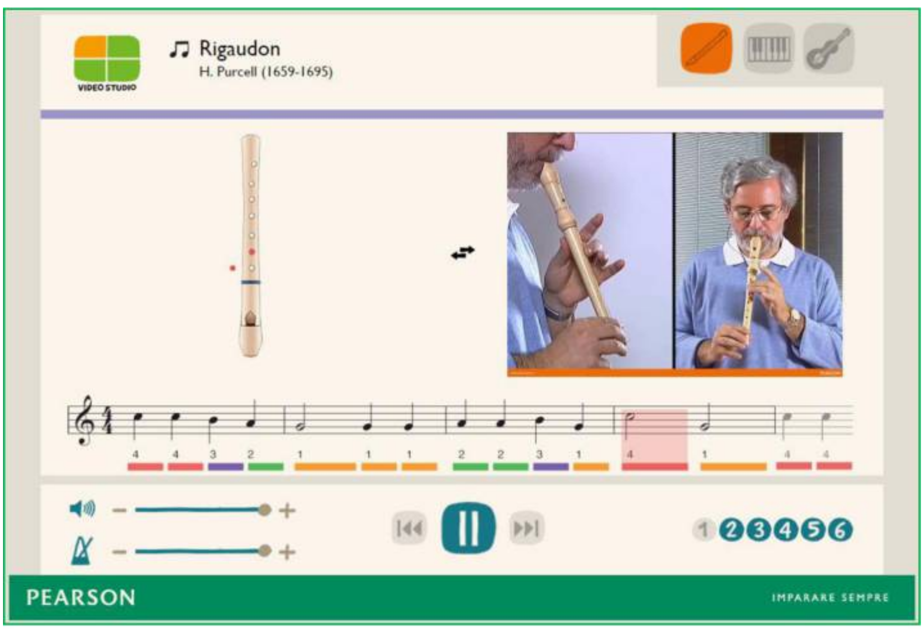
For example, “Musica live” by Vasco Vacchi, published by Pearson for the Italian market and realized in cooperation with the Università degli Studi di Milano, is a course that guides students to the practice of music through a multimedia method, called *active book*. In the early reprints, the active book was the digital transposition of the paper book, plus a number of links to allow the student access various multimedia materials. The 2014 version, which is currently on the bookshelves, has introduced a renewed approach thanks to the adoption of IEEE 1599 technology. Now attached multimedia materials are not limited to pre-recorded audio tracks. For about 100 pieces encoded in the IEEE 1599 format, a deeper interaction with contents is offered. Among the advanced features, we can cite the following ones:

- The most common music instruments played in schools are supported, namely, flute, guitar and keyboard. This multi-instrument approach implies the production of *ad hoc* materials for each instrument, including solo tracks, customized scores and specific video contents (see below). Thanks to the adoption of IEEE 1599, all media objects are mutually synchronized in a single XML document.

- Cooperative learning is supported as well. In fact, the interface of the active book allows any combination of the aforementioned instruments, so that two or more students can meet and play together, even if they want to practice different instruments.
- Some videos and animations have been produced to illustrate the technical aspects of each instrument and piece.
- Thanks to IEEE 1599, an interactive and adaptive score following has been implemented. Beside standard media controls, note- and page jumps and a tempo slider have been introduced to adapt the users' experience to their learning needs and achievements.

"Musica live" adopts W3C-compliant technologies, and it has been released both as a stand-alone offline product and as a web application, freely available to the book buyers. Its interface is shown in Figure 2.

Needless to say, the mentioned product is surprisingly advanced if compared to traditional paper books or to the early texts with digital supports, often containing only audio tracks or MIDI files. Nevertheless, in light of the most recent research and



Notes: Musica Live. Pearson Italy; section 6 will introduce a number of further design principles

Figure 2.
The Music Active Book contained in Vacchi (2014)

scientific literature, this approach can be considered as a promising experiment to be continued.

One of the aspects to improve is the limited personalization offered to the final user: contents and fruition modes are predetermined and cannot be customized according to the student's expectations or the teaching style. Besides, the active book has been conceived for a number of educational cases and learning disabilities, but it does not cover all the possibilities and, in this sense, is hard to customize: for example, a coloured notation is provided for dyslexics, but high-contrast colours are not available for visually impaired people. Finally, such a product completely lacks in social interaction. Even if designed for a web experience, it does not take any advantage from networking as regards the creation of collaborating, peer seeking and peer reviewing activities.

In conclusion, in this section we have reviewed one of the most advanced products in the field of computer-based music teaching. Unfortunately, it does not take into account the most recent theories and researches about self-regulation. In our opinion, on the contrary, starting from an up-to-date state-of-the-art is fundamental to design and implement an effective active music e-book. From this point of view, Section 6 will introduce a number of further design principles.

6. Design principles for an active music e-book

This section aims at reviewing the key features of the active e-book proposed in Section 3 to apply them to the self-regulated learning of music described in Section 2 through the technologies mentioned in Section 4. Some characteristics can be retrieved in already existing products, like the one described in Section 5; in other cases, they are proposals that can be implemented through available web-based technologies.

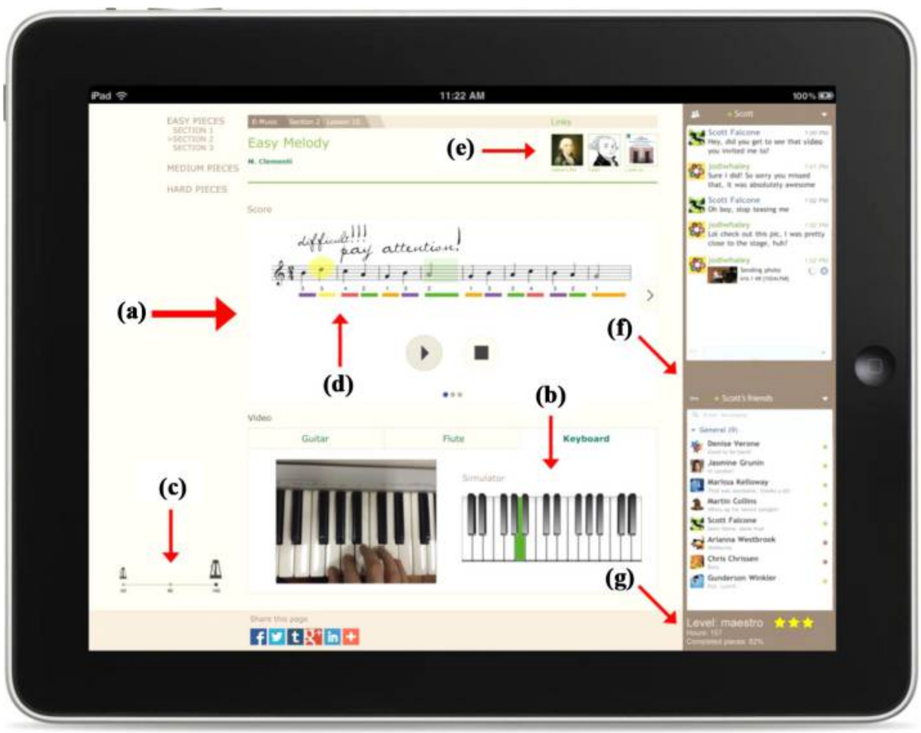
Let us go back to the definition of the three macro-phases typical of self-regulation cycle, namely, *forethought*, *performance* or *volitional control* and *self-reflection* (see Figure 1). For each of them, we can identify a number of scaffolds and consequently design a possible implementation inside an active e-book.

An instance of the proposed model can be implemented through web technologies such as HTML5, Javascript and PHP. Figure 3 shows an example of interface presenting some self-regulation scaffolds described in the following. More details will be provided below.

6.1. Forethought scaffolds

As regards forethought, a key scaffold for music learning is *computer-assisted sight reading*. This feature can be realized through an automatic score following algorithm with customizable tempo[2]. Tempo can be set either to gradually improve performance or to add goals harder to achieve. As regards the former aspect, young music students often practice a new piece at a very slow speed, and only after acquiring a basic knowledge, they increment tempo. In this sense, the interface can follow and support their progress adaptively. The latter aspect is typical of challenging performances such as studies and virtuoso showpieces.

The IEEE 1599 format is able to support sight reading, as both symbolic and graphical information are encoded in a single environment, specifically in the logic and notational layer. In this way, it is possible both to propose one or many existing printed score versions and to reconstruct notation starting from its logical description, e.g. on a linearized staff system. In a score editing software, these approaches are often called



Notes: (a) Score following; (b) audio-visual aids; (c) tempo customization; (d) handwritten annotations; (e) external links to additional sources; (f) the social part for peer seeking and collaborative practice; (g) a reward mechanism

Figure 3.
Arrows highlight a number of scaffolds

score view and *scroll view*, respectively. Then, graphical representations can be automatically scrolled at a customizable rate. As illustrated in Figure 3, the central area of the interface is devoted to score notation and score following: the current note is highlighted by a running cursor. Audio and video contents are synchronized as well.

A problem could arise when a media material is already available (like the video in Figure 3), and not generated on the run (like the animation in Figure 3). In fact, in this case tempo information is embedded inside the audio track and not inferred from score parsing. Luckily, if tempo variations are slight, say about 70-130 per cent of the original beats per minute (BPM), effective algorithms for time stretching are available and they are natively implemented in HTML5-compatible web browsers. Figure 3 presents tempo controls in the lower left corner of the interface, graphically denoted by metronome-shaped icons.

Another scaffold is asking *meta-cognitive questions* to students to improve their comprehension of the music piece. Questions can range from theoretical aspects (music scales, chords, macro-segmentation of the piece, etc.) to practical and technical aspects, i.e. the performance problems to face. In this way, students can relate encountered difficulties with their previous knowledge, and they can be redirected to *ad hoc* learning paths, potentially crossing different semantic axes. An e-book that presents not only a score to be played, but also a number of questions about its musical and extra-musical meaning may become adaptive and active in suggesting a proper path to improve learning. For instance, if a student is experiencing difficulties with a jazz piece because of its "swing notes", the interface can automatically propose links to historical performances: from the comparison between printed score and audio/video tracks, the concept of swing in jazz music can be intuitively acquired. This feature is implemented by taking full advantage of the hypertext and networking possibilities. Please note that IEEE 1599 supports synchronization between score and audio/video contents, even when performances present different timings.

Questions can be prepared a priori by domain experts, namely, teachers, instrument players and musicologists who have a deep knowledge about the characteristics of a given piece; but they can also be generated a posteriori thanks to an automatic processing of user performances. For instance, the active book can trace mouse movements and clicks on the interface to infer difficult steps from recurrent user actions.

6.2. Performance scaffolds

The second phase, namely, performance, implies a new set of scaffolds. As mentioned in Section 2, *jumping* is one of the most adopted and successful techniques to practice. A piece can be subdivided into smaller parts on the base of music sections, performance difficulties, occurrences of themes, etc. The intra-layer and inter-layer synchronizations provided by IEEE 1599 support two kinds of jump.

First, after selecting a given score version and one of the corresponding audio/video tracks, the student can enjoy them not only in a traditional (i.e. linear) way, but also jumping from a point to another, losing neither the score following nor the synchronization effect. Generally, this would require implementing a number of sensitive areas and controls in the interface. However, the mapping of music events (time position, space coordinates, mutual synchronization, etc.) is encoded inside the IEEE 1599 document, so the interface just has to parse XML content to automatically implement controls which make sensitive areas explicit. In this way, the learner can easily create jumps or loops on specific score sections.

Besides, another kind of jumps is supported. IEEE 1599 describes within a single document many concurrent digital objects (all related to the same piece), as regards both graphical scores and audio/video performances. Consequently, during a session it is possible to compare different performers or different notations in real time, simply switching from one to another. Once again, score following and synchronization are preserved.

Other performance-related scaffolds can be implemented. For instance, *noting* and *think-aloud processes* are recognized in scientific literature as effective learning tools. The possibilities offered by new technologies in the field of annotations have been often considered unsatisfactory, as discussed by Hernon *et al.* (2007) and Huang *et al.* (2012); taking notes on a paper sheet, on the contrary, is very intuitive. Consequently, the active book interface should provide easily accessible areas and support advanced devices to implement those processes.

Peer seeking, intended here as help requests to other students, is another key scaffold to improve performance. Similarly, *search for new sources*, i.e. getting further information about a given music domain, is fundamental to enrich and extend previous knowledge. Also, these scaffolds can be easily implemented in an active e-book, but they require network connectivity. Our HTML5 implementation proposal supports all of them, as shown in Figure 3.

6.3. Self-reflection scaffolds

Finally, as regards self-reflection, we have identified another set of scaffolds fit for an active music e-book. Also, in this phase, *peer seeking* can be called into question, and once again it is fundamental to improve the learning process; but in this case, it implies a comparison between personal performance on one side and performance of peers on the other. Another possibility offered by this scaffold is cooperative learning, namely, the translation of traditional classroom activities into academic and social learning experiences. This kind of peer seeking does not imply searching for a yardstick to measure personal performances against other students, but searching for other musicians of equal or similar skill to study and play with them. Web technologies, such as HTML, XML and IEEE 1599 support both mentioned approaches. Possible consequences are *gamification* and *reward* mechanisms, two approaches described in scientific literature to encourage self-regulated learning. Please note that, with an Internet connection available, this kind of music e-book could even push students towards distributed music performance.

Probing and *checking* are scaffolds referable to self-reflection, too. The former implies that students conduct systematic analysis on their conceptual map, using both causal reasoning and computer aid to locate potential errors. An example is watching videos performed and commented by professional musicians who can stimulate self-reflection. Thanks to IEEE 1599, these videos can be synchronized with all other music contents, and comments and hints can be enabled/disabled just like subtitles in movies.

As regards with *checking*, quizzes and automatically generated feedbacks on performance could help evaluating the mentioned conceptual maps.

7. Conclusion

Empirical evidences show that new media can foster musical education, having an impact on students' performances and learning rate. The most recent studies on education and didactic approaches point out the importance of students' self-regulation capabilities for an effective learning experience. Consequently, the design of traditional e-books in general – and music e-books in particular – has to be rethought according to the macro-phases the self-enhancing cycle is made of: forethought, performance or volitional control and self-reflection.

If compared to paper textbooks, e-books present advanced ways to convey contents and to enrich learning experience through multimedia and interactivity. However, in their traditional form e-books are not active and adaptive. On the contrary, the paradigm of active e-book illustrated in this work enables the transition from a passive *reading mode* to an active *study mode*. In this context, the mentioned scaffolds aim at training self-regulated learners who will be able to improve their performance and maintain high motivation in their music studies.

From a technological point of view, the implementation of scaffolds in a multi-modal, adaptive and dynamic interface is possible, thanks to the integration of HTML5 with IEEE 1599. The latter standard is an XML-based format aiming at a comprehensive description of music materials in an integrated and fully synchronized environment.

The educational approach presented in this work is driving the design of a working prototype. As discussed in Section 5, an early attempt of active music e-book is already available. However, some advanced features have been implemented only in a prototypal product. The experimentation phase will take place next year, in the context of music courses for Italian middle school. Such a product follows the guidelines of the project "Scuola digitale – Editoria Digitale Scolastica" released by the Italian Ministry of Education, Universities and Research. If successful, this experience will be repeated at the European level thanks to the cooperation with international publishers.

Notes

1. http://emipiu.di.unimi.it
2. Tempo is the speed or pace of a given piece in terms of BPM.

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