A New Paradigm for Music Education: Creating Active E-books through the IEEE 1599 Standard

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***Abstract*—After a short review about music education and self-regulation in learning processes, this paper identifies the meta-cognitive strategies that music students should adopt during their instrumental practice. The goal is re-thinking the structure of a didactic e-book for instrumental music education. Thanks to the adoption of the IEEE 1599 standard, the paper outlines a model of active e-book able to improve learners' performances through proper cognitive and multi-modal scaffolds.**

I. Introduction and Motivation for Active and Meta-cognitive E-books

Music education experiences a high drop-out rate caused by students' sense of failure. This implies a specific review of course curricula, particularly during *early childhood*, to allow them to influence and negotiate their own pathways [1]. 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 [2]. New digital technologies allow to explore new ways to design and implement active e-books and to endorse self-regulatory cognitive and meta-cognitive strategies.

As regards the self-regulation techniques that young music students can adopt, we have analyzed the research work by Zimmerman and Campillo [3]. In order to describe the self-regulated problem-solving process, they introduce the 3-phase cyclical model shown in Figure 1.

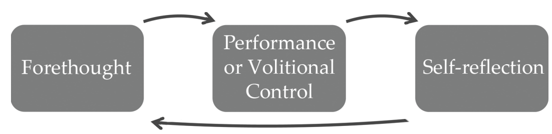

Fig. 1. Cyclical phases of self-regulated problem-solving process in the Zimmerman and Campillo's model.

The *forethought phase* is based on the concept of strategic planning and self-efficacy. An example of strategic planning for a musician is suspending the performance of warm-up material from the printed score and playing a memorized sequence. Other strategies include hand-written annotations on the score and specific techniques of sight reading [4]. The idea of self-efficacy, fundamental for any musician [5], implies the self-recognition of being a good instrumentalist. 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 [6].

In the *performance* or *volitional control phase* there are two processes that students can apply to improve their performance: self-control (self-instruction, imagery, attention focusing) and 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 [7]. In [8] the self-observation process has been decomposed into 3 kinds of representation: an aural representation of the target performance (i.e. how the piece should be played), a motor representation of the physical actions required, and finally the representation of the current performance, constantly monitored and compared to a reference performance that the musician has in mind.

Finally, the *self-reflection phase* is based on self-evaluation, causal attribution and self-satisfaction.

Through digital active books, students should be able to adjust their cognitive as well as meta-cognitive behaviors [9], [10] thanks to proper scaffolds (e.g. feedbacks and prompts). As stated in [11] and [12], scaffolds are functional to the development of specific self-regulation skills in the music field. Nowadays, the scientific community is paying a great attention to the effectiveness of different kinds of scaffold on students' self-regulation processes [13]. Results are used here to revise the design of active music e-books by using IEEE 1599, an XML-based standard for the multi-layer encoding of music contents. This subject will be discussed in the next section.

II. Technologies for an Active Music E-book

HTML5 is currently the latest release of HyperText Markup Language (HTML), a cross-platform language specially designed to deliver rich content without the need for additional plug-ins. With the release of the EPUB 3.0 specification in 2011 [14], HTML5 officially became a part of the EPUB standard. Nowadays publishers can take full advantage of its features to add media content and interactivity to their e-books. Some relevant examples are described in [15] and [16]. At the moment, many hardware and software e-book readers support this new standard. In the near future the adoption of HTML5 could make pure e-book readers obsolete, since contents will be enjoyed on general-purpose mobile devices equipped with web browsers, e.g. tablet computers. Even more so, there is a great interest towards web-based technologies for the delivery of e-book contents.

Thanks to the native support of audio/video, the adoption of HTML5 allows a number of advanced and innovative media

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applications. Nevertheless, some features oriented to music education and instrumental practice require a proper format, able to represent music contents by maintaining compatibility with HTML technologies. For this purpose we have adopted IEEE 1599, an international standard aiming at a comprehensive description of music contents that was approved by the IEEE Computer Society in 2008. IEEE 1599 adopts Extensible Markup Language (XML) in order to describe a music piece in all its aspects. Since XML is one of the standards recognized by the World Wide Web Consortium (W3C), the choice of integrating IEEE 1599 into an e-book - either in EPUB or in HTML format - perfectly fits our goals.

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 music symbols to catalog 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: general, logic, structural, notational, computer-driven performance, and audio. Music events are univocally identified through a common data structure known as the *spine*, and then instanced $[0..n]$ times in the mentioned layers. Thanks to this concept, IEEE 1599 supports two synchronization modes: i) *inter-layer synchronization*, which takes place among many descriptions of the same music event in different layers, and ii) *intra-layer synchronization*, which occurs among multiple instances of the same event within a single layer. For further details, an in-depth description of the key aspects of the standard is provided in [17].

III. An Example of Implementation

In order to validate our theoretical approach, we have designed and implemented a prototype of music-oriented active e-book. This application has been conceived to run on a wide range of devices, including personal computers and tablets equipped with HTML5 browsers and e-book readers.

Figure 2 shows a possible interface presenting advanced features. Some italic letters have been superimposed, referring to the scaffolds listed in Section IV.

The screen contains 2 areas: the *practice section* in the main area and the *social section* in the right column. The former area shows the music piece to be performed, and it presents multiple views: standard scores, a color coding for pitches, videos and animations about the performance on different instruments, etc. Additional material, such as explanatory texts and music analyses, can be enabled. Standard media-player controls, selectors and menus allow to customize the user experience. This part of the environment was built through web technologies, nevertheless most features work in an off-line context, too. The right area contains the social features, including discussion fora, virtual classes, expert supervision, etc., and it requires network availability.

As mentioned above, music materials are encoded in IEEE 1599 format. In order to produce them, a publisher needs:

- A digital score editor to transcribe music symbols and perform their translation into XML format;
- A set of digital materials to be linked and synchronized within the IEEE 1599 document, including still graphics, audio tracks, animations and video clips;
- An IEEE 1599 authoring environment, which is cross-platform and publicly available for free.

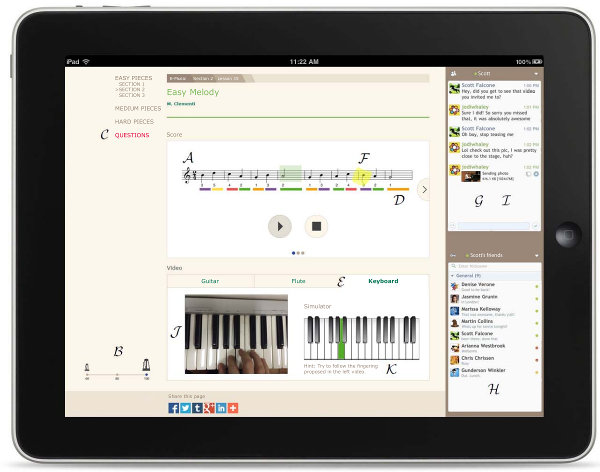

Fig. 2. Implementation proposal for an active music e-book.

IV. Scaffolds for an Active Music E-book

The implementation described in Section III directly follows from the self-regulation cyclical model by Zimmerman and Campillo. For each phase, we have identified a number of scaffolds and we have implemented them in a music active e-book. In the following, we will mark scaffolds through parenthesized letters which refer to Figure 2.

A feature oriented to *forethought* is *computer-assisted sight reading* $[\mathcal{A}]$, which requires automatic score following with customizable tempo $[\mathcal{B}]$. Please note that tempo can be progressively increased either to improve performance or to add new technical obstacles. As regards score following, IEEE 1599 intrinsically supports this aspect, since it encodes symbolic, graphical and audio/video information in a single, fully synchronized environment. Consequently, score representations (scanned as well as generated from symbols, in modern notation as well as in other graphical form) can be automatically scrolled at a given rate that the learner can customize.

Another scaffold regarding *forethought* implies asking *meta-cognitive questions* to the students in order to improve their comprehension of the difficulties to face $[\mathcal{C}]$. Answering such questions allows to relate students' problems with their previous knowledge, as well as to redirect them to *ad-hoc* learning paths, potentially crossing different semantic axes. Since the e-book has to be adaptive and proactive in suggesting learning paths, the interface proposes a number of final questions about the piece, in terms of key features (melody, rhythm, genre, etc.), musical and extra-musical meaning, and key technical obstacles. For instance, if a student is experiencing difficulties with swing notes in jazz, the interface can automatically provide links to historical performances.

Once again, implementing this feature in an IEEE 1599-based environment is trivial, thanks to its multi-layer synchronization features.

The second phase of the model requires a new set of scaffolds. *Jumping* is one of the most adopted and successful techniques to practice an instrument. A piece can be subdivided into smaller parts on the base of music sections, performance difficulties, etc. The intra-layer and inter-layer synchronizations provided by IEEE 1599 support two kinds of jump. First, the student can experience score vision together with audio listening not only in a linear way, but also jumping from a point to another, and without losing neither the score following nor the synchronization effect. This requires the implementation of sensitive areas and *ad hoc* controls in the interface $[\mathcal{D}]$. However, mappings of music events (time position, spatial coordinates, mutual synchronization, etc.) are encoded inside the IEEE 1599 document, and the interface simply has to make them explicit. In this way, the learner can easily create jumps or loops on specific score sections. As regards the other kind of jumps, it is worth recalling that IEEE 1599 describes in a single document many concurrent digital objects, all related to the same piece. Consequently, during a practice session a student can compare different performers as well as different notations in real time, simply switching from one digital object to another $[\mathcal{E}]$. Once again, score following and synchronization are preserved.

Other scaffolds to be implemented are: *annotations* $[\mathcal{F}]$ and *think-aloud processes*; *peer seeking*, intended here as help requests to other students $[\mathcal{G}]$; *search for new sources*, in order to get further information about a given music domain or to improve previous knowledge $[\mathcal{H}]$. Some of these scaffolds require network connectivity.

Finally, let us focus on the *self-reflection* phase. Scientific literature demonstrates the importance of *peer seeking*, which implies a comparison between personal performance on one side and performances of peers on the other. Another feature to implement is *cooperative learning*, namely the translation of traditional classroom activities into academic and social learning experiences $[\mathcal{I}]$. Web technologies, such as HTML, XML, and IEEE 1599 provide support to the cited approaches. Possible consequences are gamification and reward mechanisms, two ways to encourage self-regulated learning. Moreover, if a network connection is available, this approach could push students towards distributed music performances. Also *probing* and *checking* are scaffolds referable to *self-reflection*. 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 $[\mathcal{J}]$. Thanks to IEEE 1599, these videos could be synchronized with all other music contents, and comments and hints could be enabled/disabled just like subtitles in movies $[\mathcal{K}]$. As regards *checking*, quizzes and automatically-generated feedbacks on performance could help evaluating conceptual maps.

V. Conclusion and Future Work

Recent studies on music education revealed the importance of students' self-regulation capabilities in their learning experience. Consequently the design of music e-books has been rethought according to the macro-phases of the model by Zimmerman and Campillo. The goal was introducing a number of scaffolds in order to improve learners' performance and maintain their motivation high.

In this context, we have proposed a number of design principles to implement a music active e-book. From a technological point of view, the implementation of scaffolds in a multi-modal, adaptive and dynamic interface compatible with e-book standards was made possible by the integration of HTML5 with IEEE 1599.

The software prototype still requires multi-platform debugging and user-acceptance tests. The validation phase will be based on trial scenarios, using both empirical and expert-based approaches. The idea is measuring effectiveness through an assessment analysis related to the achievement of minimum learning targets and the development of self-regulation skills.

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