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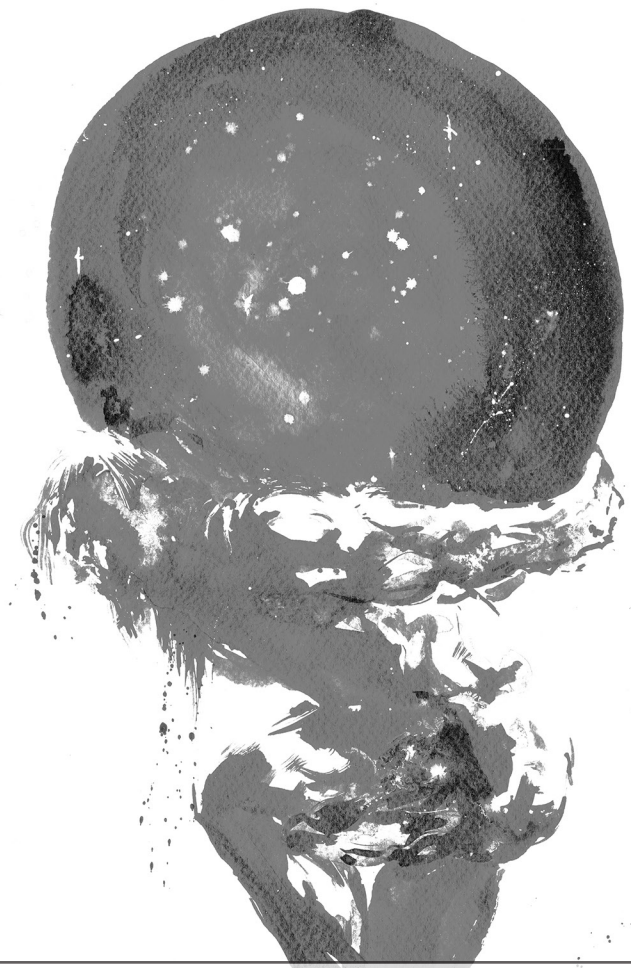

Digital Competences in Classical Music Teaching:
From a Critical View to the Systematization of Digital Resources

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DIGITAL COMPETENCES IN CLASSICAL MUSIC TEACHING: FROM A CRITICAL VIEW TO THE SYSTEMATIZATION OF DIGITAL RESOURCES[1]

Abstract: The number and variety of online classical music digital resources require specific knowledge to independently search for, select and incorporate appropriate content into the teaching process, as these represent alternative teaching tools that go beyond the primary didactic materials. The basic assumption of this paper is that the digital competences of music teachers imply not only the mastery of tools – concrete digital resources – but also a specific theoretical knowledge of music encoding, storage and transposition informed by computer science as a prerequisite for developing a skill to use digital tools. The main contribution of

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1 This research was carried out as part of the DEMUSIS project, within the preparation of lifelong learning course "Digital classical music resources as a contribution to the enhancement of music teaching" accredited by the Serbian National Institute for the Improvement of Education (ZUOV catalog number 1018). The course aimed to strengthen the digital competences of music teachers in music and general primary and secondary schools for the use of open-source classical music digital resources. The research results were presented within teaching material in Serbian "Digitalni resursi umetničke muzike kao prilozi za unapređenje nastave muzike", which was distributed to the participants during the course implementation. Here we present the derived, revised and improved version of the original text.

this article is therefore to identify the key theoretical knowledge and digital resources that music teachers should understand to successfully develop and utilize their digital competences in the context of classical music teaching. The main principles and practices of music encoding, storage, and transposition are identified and explained regarding relevant academic studies. Based on an analysis and systematization, the open-access classical music digital resources are selected and classified, considering the most representative examples.

Keywords: digital competences; classical music teaching; knowledge; open-access digital music resources; music encoding, storage and transposition; computer programs and databases.

Background

> *Google, Amazon, and other media giants will not destroy, but may well refashion our notion of the book, scholarship, and the university.*
> (Bolter 2019, 9)

The quoted statement underlines one of the main characteristics of contemporaneity: the technological intermediaries in the network of diffuse digital culture profoundly influence the traditional methods of acquiring knowledge. While on the one hand there is a fear that this will call the old values into question, on the other hand the advantages and potential of digital resources in teaching are undeniable. Digital music resources are an inexhaustible source of content that can be useful for teaching classical music. There are various open-access computer programs and structured music databases – such as collections, catalogs, archives, repositories, websites and platforms – as specific aids that have the potential for a more attractive presentation of musical topics and an innovation of the teaching process, while motivating students of all educational levels to research and learn in the field of musicology, music theory and classical music education. In this paper, we consider the existing open-access digital resources for classical music not as a means for teaching music remotely or through individual self-learning, but in terms of their potential contribution to renewing and strengthening formalized music education delivered in a physically mediated classroom environment and with traditional musical instruments.

To successfully achieve the objectives and outcomes of the teaching process in the digitally mediated world, appropriate competencies are required as "a combination of knowledge, skills and attitudes" (European Commission 2019, 5) that enable teachers to meet the requirements of the activity they are carrying out with a specific didactic tool (Sánchez-Tarazaga and Matarranz 2023). Considering the European framework, digital competencies are ranked fourth among the eight key competencies necessary for personal fulfillment, a healthy and sustainable life, employment, active social engagement, and the integration of individuals (European Commission 2019, 5).

Digital competence implies "the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society" (European Commission 2019, 10). The strengthening of the digital competences of teachers is strategically supported through *The European Framework for Digital Competence of Educators* (Punie and Redecker 2017), as the scientifically based framework (EU Science Hub). Compared to the previously published regulations that traced the development of digital competences, this framework published in 2017 represents the improved version based on the comprehension that in today's world teachers must know, among other things, a set of digital competences specific to the field they are dealing with. This framework also provides the conditions for the development of students' digital competences, because "the teacher's role in the contemporary education is not only to promote specific knowledge in individual academic areas, but also to accustom students to an appropriate and safe use of digital technologies as well as to support and empower them" (Zadnik 2021, 282). Besides the mentioned document, we also highlight the "Digital Education Action Plan 2021–2027" (European Commission 2020), which emphasizes high-performance digital education, strengthening digital competences from an early age, supporting teachers, developing advanced digital skills and ensuring equal gender representation in the use of digital technologies (Matović 2021, 11; Vlada Republike Srbije 2020/2023). Regarding the role of digital competences in the educational field in Serbia, 25 digital competences have been proposed as specific for teachers, divided into 6 categories (Kuzmanović et al. 2024, 7–8), having in mind that "modern digital technologies have the potential to support student learning through individualized teaching methods to meet the needs of each individual, to the extent that was unimaginable until recently" (Kuzmanović et al. 2024, 4).

The term *digital technology* pertains to those technological phenomena that require a computer as the main communication and working tool. However, this term does not only refer to technology but encompasses a series of processes that shape the lifestyle and behavioral system of individuals. These are described by the term *digital culture*, which over the last few decades primarily encompasses the Internet and the World Wide Web, the development of mobile technologies, platforms and applications (Gere 2002). What digital tools have brought with them is the digitalization of analog data on the one hand, and the compression and structured storage of a large amount of data in databases on the other. Digital technology "introduces new degrees of both automaticity and flexibility into the process" of classification (Bolter 2019, 140). The volume of knowledge is growing rapidly and with it the methods of acquiring knowledge, to such an extent that "the very notion of what a school is, is changing and expanding […]. Digitally enabled educational activities […] can be adapted to instructors' and students' needs and have been linked to higher grades and greater student satisfaction and motivation in both children and adults" (Chayko 2016, 184). Although the use of digital technology does not exclude the use of traditional techniques and media, they significantly influence the reflection of the relationship between old and new ways of learning: "Injecting digital technologies into the classroom necessarily affects our relationship with every other communications technology, changing how we feel about what can or should be done with pencils and paper, chalk and blackboard, books, films, and recordings" (Jenkins et al. 2009, 7). Digital technologies enable the creation of a specific educational environment in which different formats and tools for knowledge transfer are available as a means of teaching and learning within a multimedia interactive experience that requires cognitive engagement from students that goes beyond the traditional framework of knowledge and learning (Raschke 1999). In other words, today's educational conditions imply a significant level of participation, which especially applies to younger generations. These can be characterized as an "ideal learning environments" or "informal affinity spaces" because "they depend on peer-to-peer teaching with each participant constantly motivated to acquire new knowledge or refine their existing skills, and because they allow each participant to feel like an expert while tapping the expertise of others" (Jenkins et al. 2009, 10). These conclusions could be applied to the sphere of musical education as well. The results of studies concerning the use of digital technologies in music

teaching indicate that – from primary school onwards – "students need access to computer programs that enable them to express themselves musically (listening, playing, singing and moving to music as well as composing) and to focus their activities on certain elements of music" (Šimunović 2013, 229).

Both positive and negative aspects of the use of digital technologies in music education were identified. For example, it was found that working with music software "has enabled pupils to understand better the relationship between music and visual images" (Cain 2004, 216). Also, "the ability to research musical topics on the Internet requires pupils to learn research skills, such as selecting relevant material and rejecting what is irrelevant. […] The ability to create music, layer by layer, to edit any aspect of it and to play it back at virtually any tempo has meant that children are now able to compose music that they cannot physically play" (Cain 2004, 216). Digital technologies allow musicians "to take an interest in the phenomenon of musical sound itself, which can lead to a change in priorities for composers and a move away from traditional musical components such as melody, rhythm and harmony, as the focus shifts to the exploration of sound itself" (Savage 2007, 73). It also raises the question of whether composing involves the manipulation of pre-existing sound samples, and "what the relationship between the performer and the listener is when the performance of music is mediated by a computer" (Cain 2004, 217).

On the other hand, the problems related to the introduction of digital technologies in the process of music learning refer to the weakening of conventional musical skills in certain cases, the greater insecurity of students in live performances, and the inability to distinguish between quality and quantity in the creation of music (Savage 2007, 69–70). One of the reasons is that "the music education system to this point in history has been rooted in traditional beliefs and values towards the production of musical sounds linked with musical instruments and the skill to play them well. […] The majority of teachers interviewed were anxious to maintain this dimension of music education" (Savage 2007, 74). The biggest change that has come with the introduction of technology into music schools has been seen in the area of composing, where technology has brought new tools and approaches, allowing even those students who do not have the traditional skills of a musical instrument to engage with music making. The situation becomes more complex by the spreading of artificial intelligence into the sphere of music and musical education (see: Holland 2000).

If we consider creating, performing, and listening to music as basic musical activities, digital technology in some ways challenges this traditional classification, since when working with music software, none of the activities can be simply labeled in the usual way (Cain 2004, 217). The conclusion is that introducing any kind of technology in music education should support, strengthen and improve existing music education rather than revolutionize it. Some authors therefore conclude that incorporating music technology in teaching is good if students behave primarily like traditional musicians (Mills and Murray 2000, 140). In this sense, our point of view is that digital technology does not threaten traditional ways of learning but builds on them and partially reshapes them intending to rethink the process of efficient knowledge acquisition. Having in mind that media/technological literacy should become an important social skill, technological knowledge should expand existing competencies, "not push aside old skills to make room for the new" (Jenkins et al. 2000, 28).

Aims and Methodology

The number and variety of classical music online digital resources require specific knowledge to independently search, select and implement appropriate digital content into the teaching process, as these represent alternative tools beyond the primary didactic formats of printed scores, books and recordings with which music teachers are already familiar. Here, we understand knowledge as "composed of the concepts, facts and figures, ideas and theories which are already established, and support the understanding of a certain area or subject" and skills "as the ability to carry out processes and use the existing knowledge to achieve results" (European Commission 2019, 5). With this in mind, in our paper, we want to select the most important principles and practices that music teachers need to know about from the rapidly growing and extremely complex field of digital humanities and music (Urberg 2017). The basic assumption is that the digital competences of music teachers imply not only the mastery of tools – concrete digital resources – but also a specific theoretical knowledge of music encoding, storage and transposition, informed by computer science (Gujar and Crawford 1986), as a prerequisite for developing a skill to use a digital tool. If music databases and programs are the end products of structuring the variety of

digital music data, it is important for teachers to know some basic mechanisms, technical aspects, and key terms of music digital encoding to be able to understand and explain different possibilities of working with digital music and music-related data. An "individual should understand the general principles, mechanisms and logic underlying evolving digital technologies and know the basic function and use of different devices, software, and networks" (European Commission 2019, 10). The main contribution of this article is therefore to identify the key theoretical knowledge and digital resources that music teachers should understand to successfully develop and utilize their digital skills in the context of classical music teaching.

To make an appropriate selection of knowledge, an analytical and critical approach has been applied to two types of research material: 1) relevant academic literature on digital humanities related to music, and 2) concrete online classical music digital resources selected to provide a comprehensive overview of the situation. First, the main principles and practices of current technological achievements in the field of music encoding, storage and transposition are identified and explained concerning relevant academic studies (1). Then, based on an analysis and systematization, the open-access digital resources for classical music teaching are selected and classified, considering the most representative examples (2).

MAIN CONTRIBUTION

1. Key principles and practices of digital music encoding, storage, and transposition

A musical work exists reified through concrete physical formats as the basis of musical practice (Lewis 2016). For classical music, the two most important forms of reification are musical scores and audio recordings. Digital technologies update the problem of encoding and storing these formats, bearing in mind that their digital transposition requires appropriate computer methods of data processing, organization, description and connection, as well as intuitive and flexible user programs that enable navigation, search, and analysis of relevant information from digital collections. For example, a score may be in a digital image format or a digital, computer-readable, encoded format. This difference

is important because the image of a score is a collection of pixels whose content cannot be automatically processed by software algorithms, which is not the case with the computer digital encoding methods (Margounakis and Politis 2011). In addition to these two formats, there is also a category of encoded scores suitable for computer performance (MIDI standard) and digital scores suitable for computer musical analysis. Scores adapted for musical analysis are encoded according to the so-called Kern scheme (Ríos-Vila et al. 2023, 349). The best-known software for computer analysis of such encoded scores is Humdrum.

The digital conversion of scores can therefore be done in two ways: by scanning – to obtain digital images of scores in TIFF, JPG or PDF format – and by encoding – to obtain digital symbolic representations of scores that are converted into formats such as MusicXML, LilyPond, Kern or MIDI. This second process is carried out as part of the digital heritage of Western European classical music within the framework of Optical Music Recognition (OMR) and the so-called Music Encoding Initiative (MEI).

OMR practice was introduced in the late 1960s and was intended to overcome the challenges posed by the different notation systems – medieval notation, lute tablature and modern notation. Another challenge was the differences in the precision of visual recognition between clearly printed music editions and manuscripts, which are often confusing and not as cleanly notated. Today, there are several commercial and some non-commercial OMR programs. The three most popular commercial programs are SharpEye, SmartScore and ScanScore. The second and third are adapted for printed scores, while the first enables music manuscripts to be recognized. Three well-known examples of non-commercial OMR toolkits are Gamera, Audiveris and Aruspix (Thomas et al. 2012, 8; Hinchey 2021).

The development of the Music Encoding Initiative (MEI) standard began in 1999 at the University of Virginia intending to create a comprehensive and computer-readable archive of notated music as a basis for music performance and research ("An Introduction to MEI"). As explained: "The work of the MEI focuses on creating a core set of rules for recording physical and intellectual characteristics of music notation documents. [...] The intellectual model governing the design of the MEI schema divides notation functions into four information-carrying domains: logical, visual, gestural and analytical. […] MEI adds a fifth domain, the bibliographic, which captures extensive information

about sources, authors, provenance and many other bibliographic details. The intersection and interplay of these five domains is where the true digital edition emerges from an encoding" (Roland, Hankinson, and Pugin 2014, 609–610). Thus, since 2003, within the Edirom project a set of tools has been developed for the creation of digital critical academic editions of musical works, developing MEI standards with the problem of harmonizing digital facsimiles and their critical annotations. These tools were then used in other projects to create customized repositories of classical music: Beethovens Werkstatt and Bruckner online, where music notations are expertly described using the Edirom tool, then in the case of the multimodal repository Freischütz Digital, which brings together digital versions of the libretto, various editions of the score and a large number of audio/video recordings of performances, and in the structuring of the Gesualdo Online and Measuring Polyphony repositories, where a significant body of modern and early modern notation is encoded in a computer-readable format available for further research and analysis.

Technically speaking, the MEI standards for encoding music into a computer-readable data structure are based on the XML markup language. Today, MusicXML is the standard format for the digital transposition of sheet music and its shared use on the Internet. The music notation represented in this format enables the automated computer processing of sheet music at the music-theoretical level of analysis. Encodings that adhere to the MEI scheme represent a musical data set comprehensively over granular hierarchical structures in which each granule can be assigned a unique identifier – a resource name. In other words, the hierarchical MEI structure of granular data allows each element of a piece of music to be identified and described by a Uniform Resource Identifier (URI) at different levels of granularity, from a piece of music as a whole down to a single note. When searching for material on the Internet, this also enables the creation of linked data and the development of interactive web applications and user interfaces that find and connect physically widely disparate music notations digitalized according to MEI encoding rules (Weigl et al. 2021).

However, the linking of different music databases is questionable if the databases function as closed silos of music data. The reason for this is often the use of individual vocabularies and standards when describing digital music files at a granular or metadata level. In addition to digital sheet music, music archives also contain digital audio files of music in WAV or MP3 format. The

inconsistency of music formats and the description standards used leads to the problem of linking and sharing multiple data sets. This means, for example, that different editions of a score and different performances of the same piece of music cannot be compared with each other. Therefore, a consensus on the encoding format and the way of digital sheet music and audio recording mark-ups is crucial for organizing and indexing large music collections.

It is about the process of unifying the encoding standards of sheet music to create semantically meaningful and functional data sets in the online space that represent the same musical composition and are located in remote music collections (Thomas et al. 2012, 4). "When MEI encodings are matched to performance recordings, through manual or automated alignment processes, they can […] [provide] a basis for FAIR multimedia publishing and communication of musicological materials […] and […] semantically enriched digital music objects" (Weigl et al. 2021, 21). At the heart of the FAIR principle of data storage – Findable, Accessible, Interoperable, Reusable – is the ability of computer systems to find, access and use existing data on the Internet with minimal or no human intervention, and to provide computer support for working with data that is constantly increasing in number, complexity and speed of creation (Wilkinson et al. 2016).

In the field of organizing and linking music databases consisting of different types of formats, this principle has been implemented through the creation of a flexible software platform Music Encoding and Linked Data (MELD) which makes it possible to combine digital representations of music – notations and audio recordings – with contextual and interpretative knowledge about music. As part of the TROPMA project launched in 2020, a virtual environment has been developed that aims to integrate data from publicly accessible music repositories according to the FAIR principle. The aim of the TROMPA project is not to copy descriptions from existing repositories into a central database that uses a standardized data representation scheme, but to describe existing data and objects by reference. The URI protocol is used to address and connect the contents of the repositories and to create layers of extended descriptors that remain hosted on their primary websites (Weigl and Goebl 2021; Weigl et al. 2021).

The two contributions mentioned were realized within the framework of the technological standard of the Semantic Web, which enables the creation of a

computer-readable data network (Raimond et al. 2007; Raimond et al. 2008; Mora-Mcginity et al. 2016). Such a data network consists of interconnected ontologies – a structured set of terms and concepts relevant to the description of digital objects in a particular internet domain. In the case of music, it is the *Music Ontology* as a framework for the distribution of structured music-related data on the web, which was first published in 2006 ("The Music Ontology"; Raimond et al. 2007; Raimond and Sandler 2012; Wu and Shi 2016). The technology of the Semantic Web offers access to a multitude of different settings of a piece of music via suitable user programs, that are stored in their digital transpositions in separate databases.

Therefore, the ability to link, search and analyze large amounts of digital music and music-related data is the most important principle in the above-mentioned practices of digital encoding, storage and transposition of music. As a result of these practices, databases are created as structured sets of digital music objects and related data that support the storage, but also retrieval, analysis and processing of data. In the context of a computer-mediated culture, understanding the basic genesis of structuring and presenting digital music data can provide a useful foundation for further research, application and a deeper relationship with technology to music teachers.

2. Key classical music open access digital resources

In the following, we interpret selected classical music digital resources by classification and divide them into two main groups according to their purpose and potential function in music teaching:

2.1 digital resources for teaching basic musical skills: creating (composing and notating), performing (singing and playing) and perceiving music;

2.2 digital resources to strengthen contextual and interpretative knowledge of classical music.

2.1 Digital resources for teaching basic musical skills

This group includes computer programs, websites, applications, and platforms, as well as mobile applications, that we refer to as digital tools for learning music. By this we mean a range of disciplines that systematically deal with various aspects of the creation, performance and perception of music:

Music Theory, Solfeggio, Harmony, Counterpoint, Theory of Musical Forms and Orchestration. This group of resources can be used as teaching tools for the above disciplines or as potential tools for improving the various musical skills of students at different levels of learning: perception, listening capability, memorization and reproduction of melodies, rhythm, harmony and the ability to understand tonality. The main feature of most of these tools is that "the student is constantly in 'control' of their playing. This is achieved by marking the notes played with appropriate colors when the material is mastered, by controlling the rhythm through the sound of the metronome when the student wishes, and by allowing the student to practice various musical parameters specifically – melody, rhythm, agogics, dynamics, and there are also numerous options for accompaniment and other elements that facilitate learning" (Prodanov, Crnjanski, and Milojković 2021, 89).

Programs	
Audacity	audio editing and recording.
LenMus Phonascus	"studying music theory that allows you to focus on specific skills and exercises, on both theory and aural training".
Lilypond	"engraving complex notation, early music, modern music, tablature, vocal music, lead sheets, educational materials, large orchestral projects, customized output, and even Schenker graphs."
Minuet	music theory education software for beginners, amateurs and music enthusiasts.
MuseScore	notation.
Nootka	understanding "the basics of music notation: reading and practicing playing musical scores […] in real time checks if the notes were played correctly."
Vocal Remover and Isolation	"separate voice from music out of a song creating a karaoke version of the song (no vocals) and acapella version (isolated vocals)."

Websites, applications, and platforms	
Dave Conservatoire	"a music school for everyone".
Good Ear	ear training.
Hansen Media	collection of "Music Theory courses and resources for both students and instructors."
Harmonagon	"uses simple geometric shapes to teach music, compatible with every instrument and style of music."
Metronom online	digital metronome.
Music Courseware	perception of tones, scales, intervals, tonality, chords, and harmonic functions.
Musictheory.net	music theory lessons, exercises, and tools.
Open Music Theory	"interactive, online textbook for college-level music theory courses."
Open Sheet Music Education	"generator of MusicXML sheet music primarily aimed at music teachers and musicians, who manually create exercises for improving sight reading skills for their instruments for themselves or their students."
Pojmovnik muzičke teorije	Music Theory glossary of the Serbian Society for Music Theory.
Rhythm Trainer	rhythm perception training.
Teoria.com	"dedicated to the study and practice of music theory and the development of aural skills."
Theta Music Trainer	"games for ear training and Music Theory."
YouTube	Music Matters, Christopher Brellochs and Adam Neely; in the local context, in the Serbian language: Muzikul, Muzička kultura – muzika za osnovce, Jaccoled C and Pevaj sa Sandrom

Mobile applications	
Bring Back the Beat	Various applications on Google Play and in the Apple Store, in the Music Appreciation Apps category, for practising playing, singing, acquiring knowledge of music theory and music history, as well as applications for composing and notating – for younger age groups and children who are in the process of musical literacy. For more on mobile applications and their use in teaching solfege and music in primary school see Jeremić 2020.
Noten learnen	
Rhythm Teacher	
Solfeg.io	

2.2 Digital resources to strengthen contextual and interpretative knowledge of classical music

These digital resources include collections for performing and listening to, analyzing and researching classical music. They differ in their organization, the topics and the formats they contain.

The open-access search engine Digital Resources for Musicology of the Packard Institute for the Humanities (Stanford University) lists over 300 open project presentations on thematic and diverse areas of classical music. The search engine was first structured in 2014 to make sense of the growing field of heterogeneous music resources available online (Nikolić 2023). It is complemented by Harvard University's Online Resources for Music Scholars, which serves as a search engine for various content relevant to Historical Musicology, Ethnomusicology, Music Theory, composition and performance practice. The idea behind both search engines is to create a database of links to relevant websites to facilitate online searches on various musical topics. Both engines are in open progress – they are updated regularly with new information. Most of the examples we have selected as important resources for developing contextual and interpretive knowledge of classical music are also part of the Digital Resources for Musicology. In this category we have divided the selected examples into seven subcategories according to the type of content:

2.2.1 Databases with music-related metadata and catalogues
2.2.2 Repositories for sheet music
2.2.3 Composers – life and work
2.2.4 Historical and contemporary music audio and video recordings

2.2.5 Music iconography databases
2.2.6 Resources for researching the history of Music Theory and Aesthetics
2.2.7 Other

2.2.1 Databases of music-related metadata and catalogs	
Cantus Index	"a catalogue of chant texts and melodies for the liturgical Office and Mass, and a search of online chant resources." It combines the databases of 11 projects, all of which follow the same standards for texts and music encoding. It is possible to search for both texts and melodies.
Chopin Online Catalog	catalog of the first editions of Chopin's compositions – 85 compositions printed before 1881 and found in various collections of European and American libraries.
MusicBrainz	"an open music encyclopedia that collects music metadata".
RISM	"comprehensively document extant musical sources worldwide: manuscripts, printed music editions, writings on music theory, and libretti that are found in libraries, archives, churches, schools, and private collections. […] records what exists and where it can be found." Muscat is also created as a special open-source program for projects describing primary music sources, digitizing them and linking them to the RISM catalog (Ward 2017).
RILM	the most important bibliographic catalogue of writings on music.
RILM abstracts of music literature	among other things, it contains more than 200 full-text music journals.
RILM Music Encyclopedias	presents full texts on the most important areas and topics of Historical Musicology, Ethnomusicology and Music Theory in a comprehensive, encyclopedic manner.
MGG online	"the preeminent digital encyclopedia for music researchers worldwide."
Index to Printed Music	"the digital finding aid for locating musical works contained in published collections, sets, and series."
RILM Publications	"bibliographies for a collections of scholarly essays on the history of academic disciplines."

Sheet Music Consortium	"grouping of libraries working toward the goal of building an open collection of digitized sheet music using the Open Archives Initiative Protocol for Metadata Harvesting."
Stockhausen Concerts Database	contains data on all concerts at which Stockhausen's music was performed in the period from 1952 to 1972.
ViFaMusik	a virtual musicological library in the format of an aggregator of web links grouped into several categories: choral music and folk music from different parts of the world – photos, videos, podcasts and descriptive materials.

2.2.2 Music sheet repositories	
Art Song Central	"printable public domain sheet music for singers and voice teachers. An emphasis is placed on standard classical and traditional repertoire."
Bodleian Library Broadside Ballads Catalogue	a collection of sheet music of English ballads from the 16th to the 20th century.
Digital Scores and Libretti from the Collections of the Eda Kuhn Loeb Music Library	"digital collection of scores and libretti, selected for their rare or unique natures and their popularity as objects of research and teaching."
Early Music Online	Contains "over 320 volumes of 16th-century anthologies of printed music, from holdings at the British Library."
IMSLP	also known as the Petrucci Music Library – one of the most important and largest collections of sheet music. An important source for musicians and researchers looking for printed editions of classical music, with multiple editions of a single composition.
Jean-Baptiste Lully Collection	scores of nearly 30 rare 17th- and 18th-century opera, ballet, and movement scores written by Lilly and his sons.
Juilliard Manuscript Collection	140 autograph manuscripts, sketches, engravers proofs and first editions of works by various composers.
KernScores	library of encoded music scores in Humdrum kernel format, over 100,000 files.

Open Score	public domain music scores in MusicXML format created by a community of enthusiasts, for download, performance and editing; standard and classical repertoire.
Music Manuscript Online	over 700 manuscripts of music by the most important composers from the 18th to the early 20th century.
Mutopia Project	score, 2124 compositions in open access for download in PDF and MIDI formats, as well as for editing in the LilyPond program.
Sheet Music International	"music library of the world's greatest music."
The Computerized Mensural Music Editing Project	encoded scores of early music together with software tools that make them accessible to musicians and researchers.
The Düben collection with catalogue	scans of facsimiles and annotations of a large collection of music manuscripts and scores from the 17th and 18th centuries.
The Lost Voices Project	16 sets of books published by the Parisian printer Nicolas Du Chemin between 1549 and 1568, containing facsimiles, contemporary transcriptions, scholars' commentaries and research tools; digitized according to MEI standards.

2.2.3 Composers – life and work	
Arnold Schönberg Center	extensive collection; film recordings, personal documents and photographs, biographical sources; sketches, manuscripts, theoretical, pedagogical and literary works, lectures, teaching materials; personal documents; complete Schönberg library; programs, posters; audiovisual documents.
Bach Digital	almost complete digital library of all works by Johann Sebastian Bach and his sons as well as other primary sources on their work; resources of the Bach Archive in Leipzig, the University of Leipzig and the National Libraries in Berlin and Dresden.
Beethoven Autographs online	Centre for Beethoven Research, Boston University; collection of Beethoven manuscripts: fragments, cadenzas, sketches, but also complete manuscripts from libraries and private collections throughout Europe and North America.

Beethoven-Haus Bonn	a huge collection of digitized material: over 6,000 documents, over 37,000 scanned pages of sheet music and high-quality manuscripts, 1,600 audio recordings of compositions and audio letters, 7,600 text files.
Beethoven Werkstatt	digital critical music edition; presentation of the genesis of certain compositions, comparison of sketches and various editions of Beethoven's compositions.
Brahms digital	various types of material on Brahms' life and music: autographs, early editions, letters, concert programs, drawings, photographs.
Bruckner online	digital catalog of Bruckner's works, scanned images of about 700 autographs; digital copies of early printed editions; an encyclopedia with information on his life and works; MEI-encoded scores with computer harmony analysis; quotations about Bruckner from previous literature – almost 10,000 citations.
Digital Interactive Mozart Edition	the most important part of the Digital Mozart Edition (DME), developed by the Mozarteum Foundation in Salzburg and the Packard Institute for the Humanities, Stanford University, which consists of several thematic collections: music, libretto and poems, letters and documents, sources and catalogues, reception and interpretation, Mozart's library. It is possible to listen to the compositions synchronized with the sheet music.
Edvard Grieg Archive	shortly before his death, Grieg decided to donate his legacy to the Bergen Library; the digitization project began on the composer's 150th birthday in 1993.
Gesualdo Online	critical digital edition of the complete works of Gesualdo da Venosa; 200 arranged compositions and 39 references to musical sources; the download is free and the edition is available in three formats: pdf, Sibelius and MEI files.
John Cage Living Archive	manuscripts and video materials.
Schubert Online	documentation on Schubert's life and work; 636 autographs, letters and other materials.
Swedish Musical Heritage	a collection representing Swedish composers through various formats of copyright-free material: biographical information, scores, recordings.
The Aaron Copland Collection	a comprehensive collection of everything to do with Copland's life: Manuscripts, sketches, typed speeches, photographs (about 5,000), childhood memories, letters, 981 digital items in all.

2.2.4 Historical and contemporary music audio and video recordings	
Archives Sonores CNRS	the digital archive of the Center for Ethnomusicological Research based in Paris; contains a catalog with data on music recordings on various sound carriers since 1900; about 30,000 recordings, of which about two thirds contain sound; 5,000 recordings are classified as rare.
Berliner Gramophone Disc Collection	a digital collection of records published by Berliner Verlag between 1892 and 1912.
CHARM Archive	the result of a project aimed at researching the history of music exclusively based on sound recordings; contains around 5,000 recordings. Interesting collection: The House Conductors – biographies and discographies of eight famous conductors from the period after the advent of the gramophone.
Classical Discography	a catalog of classical music records found in the archives of major publishers in Europe, America and Japan. It consists of commercial LP records from the period 1950 to 1979, supplemented by a small number of examples dating back to 1980, i.e., the period before 1950; contains no audio samples.
Europeana	the largest digital collection of European cultural heritage, which collects digitized material from more than 3,500 European institutions intending to facilitate and promote its use. A special project – Europeana Sounds – with the slogan "the sound heritage of Europe at your fingertips". Over 600,000 recordings, divided into the following groups: music (all genres), spoken performances (historical speeches, interviews, stories, theatrical performances, recitation, languages and dialects), environmental sounds (animal sounds, ambient sounds and recordings of soundscapes of large cities), radio programs (news, documentaries, radio broadcasts) and sound effects. Over 300,000 files linked by recordings: scores, music manuscripts and images.
Europena Music Collection	a thematic digital exhibition dedicated to Europeana's music collections; each month, a specific institution is responsible for the digital design and presentation of a specific musical theme related to a music collection that the institution owns.
Geman Music Archiv	the largest non-commercial collections of sound recordings can be found in specialized music archives and libraries, which are often part of national libraries. However, these collections are usually not open to the public, except for use on a computer network within the institution to which they belong.

Internet Archive	contains 15 million of sound recordings – music of all genres, audio books, sound archives, important radio news, political speeches, organized by collection. There is also a subcategory containing recordings of concerts by famous world musicians.
Ivey Collection of Electronic Music	a collection related to the work of the first electronic music studio established in 1969 at the Peabody Conservatory, Johns Hopkins University; recordings of 234 works.
Muzickweb	over 600,000 compact discs and 300,000 LPs described according to international library standards; contains digitized audio recordings that can be used for analysis, as well as high-quality metadata.
New Zealand Pianola Site	recordings of music for mechanical piano, period from 1900 to 1930, over 3,500 files.
Silent Film Sound and Music Archive	silent film music archive, for research and performance.
The Gleen Gould Archive	a collection of tapes, mainly from the 1970s and 1980s, showing Gould as a performer, at home, in concert, in the studio.

2.2.5 Music iconography databases	
Bildpostkarten	historical music postcards; postcards from the period from 1880 to 1945 showing musical scenes: portraits of composers, musicians, composing, performances.
Digital Image Archive of Medieval Music	originally a website for viewing rare manuscripts in various image sizes and resolutions; today it is a unifying website of various projects dealing with mediaeval music, containing detailed information on all known sources of European polyphonic (vocal) music, high quality images and manuscripts.
Early Music Sources: Iconography Database	iconographic database of early music: images, instructions, music performers.
Iconoteca	portraits of musicians; a collection of painted portraits of composers and musicians from the 18th century, then lithographs, photographs of musicians and composers; over 1,500 objects that were often used to illustrate book editions and concert programs. It also contains over 6,000 letters.

Joseph Muller Collection of Music and Other Portraits, New York	contains over 6,000 portraits of musicians and composers, which were often used as the basis for illustrations in music publications. The pictures date from the 16th century to the early 20th century; they are drawings, lithographs and engravings.
Jaconde (Mona Liza)	French national catalog of museum exhibits with a tool for finding exhibits related to music.
Louvre digital collection	contains half a million photos (pictures, objects, books and other types of material), including those related to music.

2.2.6 Resources for researching the history of Music Theory and Aesthetics	
Early Music Theory	digital edition of the theoretical works of Johannes Tinctoris.
Saggi musicali italiani (SMI)	archive with texts on music theory and aesthetics, in Italian, from the Renaissance to the 19th century.
Thesaurus Musicarum Latinarum (TML)	archive of texts on music theory and aesthetics in Latin; the idea of making every known Latin text on music, from late antiquity to the 17th century, searchable by transcribing the original sources.
The Traités en français sur la musique (TFM)	texts in French, from the Middle Ages to the 19th century.
Treatises on Music in English (TME)	texts in English, from the 14th to the 18th century.
Thesaurus Musicarum Italicarum	musical treatises in Italian, from the Renaissance to the early Baroque period; among them the works of the most famous Italian authors of that period, Pietro Aaron and Joseph Carlino.

2.2.7 Others	
Freischütz Digital	digital critical music edition; combines digital versions of the libretto, various editions of the score and a large number of audio/video recordings of the performance.
Historical Tenors	editions of records and information about singers, tenors.
MDZ digital music collections	various thematic collections of music manuscripts, scores, autographs, libretti, music literature, including materials from the Bavarian State Library.

Measuring Polyphony	platform for the encoding of late medieval music; modern and early modern notation are encoded in a computer-readable format that is available for further research and analysis.
MIMO	Musical Instruments Museum Online – the largest database of information about musical instruments in public collections.
Monuments of Partimenti	a collection of musical instructions that once served as training exercises for musicians at European courts.
Music Gifts for the Russian Emperors	a collection of music given to the Romanov imperial family by visitors from France, Italy, Germany and other countries in the period from the 18th to the 20th century. Many gifts also came from Russia itself, where Western European music was introduced at the beginning of the 18th century.
The Cello Music Collection of the University of North Carolina at Greensboro	the only database dedicated exclusively to the cello; contains sheet music, monographs, videos, personal documents related to cello music.
The International Harp Archives at Brigham Young University	a selection of harp music scores and other materials, from the 18th to the early 20th century.
The Library of Congress: The Moldenhauer Archives	over 3,500 documents of Western classical music, from the Middle Ages to the present; music history from primary sources.
VifaMusik Libretto Portal	catalogue of the libretti of the Bavarian State Library, the Frankfurt University Library and the German Institute in Rome; over 8,000 libretti of operas, oratorios and ballets from the 17th to 19th centuries; it is possible to search by criteria of the composer or the name of the work.
Virtual Music Rare Book Room	the focus is on rare music editions, especially sheet music, in particular French operas of the 18th century.

Implications

Systematizing and classifying open access classical music resources is essential due to their vast number and diversity. While the presentation of the principles and practices of digital music encoding, storage and transposition is designed in a linear narrative flow of text, this systematization is done by structuring lists of the main categories of digital resources and specific examples within each category, accessible via hyperlinks, considering that this list is exemplary, but by no means final. Intentional structuring of this section of text as a collection of listed items reflects the logic of the database as a prevailing way of understanding the world in the computer age (Manovich 2001, 219–221). In other words, the chosen methodology that resulted in this conceptual framework reflects the complexity of the contemporary technological context, which can be described by the phrase "digital plentitude" – "a universe of products […] and practices […] so vast, varied, and dynamic that is not comprehensible as a whole" (Bolter 2019, 8). By writing a text in which the perspectives of linear and structured thinking are equally engaged, we put forward the initial thesis that digital competences in music teaching require both narratives of computer science-based theoretical knowledge about the encoding, storage and transposition of music and knowing of programs and databases as the outputs of these practices, functionalized as concrete digital teaching tools.

Acquiring relevant theoretical knowledge is crucial for music teachers to effectively apply digital competencies in demonstrating their expertise within the specific context of the educational process. The availability of digital resources represents an additional category of knowledge that enhances music teachers' ability to apply digital technologies in the music education process and develop the necessary skills. If "engagement with digital technologies and content requires a reflective and critical, yet curious, open-minded and forward-looking attitude to their evolution" (European Commission 2019, 10), then possessing specific knowledge and skills is necessary to foster a positive attitude as the third element of competence alongside knowledge and skills. But "at this moment, we identify the teachers who quickly recognize the pedagogical potential of digital technology and easily adapt it to the needs of their students, and the teachers who resist it, even though the transformation of teaching practice is necessary to adapt

the school to the reality deeply touched by technological progress" (Kuzmanović et al. 2024, 5). However, it is certain that things are not always black and white, and it cannot be said definitively whether technological influences are certainly good or bad. Here, we will refer to Sherry Turkle, who states: "At every step we have to ask, as educators and citizens, whether current technology is leading us in directions that serve our human purposes. Such questions are not technical; they are social, moral, and political. […] Technology does not determine change, but it encourages us to take certain directions. If we make those directions clear, we can more easily exert human choice" (Turkle 2004). Furthermore, this situation is complicated by the rapid pace of innovation, and it is also uncertain whether we can effectively keep up with every new technological development in the educational process.

We hope that the presentation of the main principles and practices of music encoding, storage and transposition as well as the systematization of various and numerous classical music online digital resources will support the formation of a conciliatory and acceptable attitude towards the role of digital technologies in the music teaching process and support the development of digital competences of teachers. The presentation of knowledge and tools as key principles, practices and examples of music encoding programs and databases is intended to help and encourage teachers to understand the mechanisms of technologically mediated knowledge transfer, successfully navigate the multitude of resources available and select those that meet the specific objectives and outcomes of each subject and lesson.

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DIGITAL COMPETENCES IN CLASSICAL MUSIC TEACHING: FROM A CRITICAL VIEW TO THE SYSTEMATIZATION OF DIGITAL RESOURCES (summary)

The number and variety of online classical music digital resources require specific knowledge to independently search for, select and incorporate appropriate content into the teaching process, as these represent alternative teaching tools that go beyond the primary didactic materials. The basic assumption of this paper is that digital competences of music teachers imply not only the mastery of tools – concrete digital resources – but also a specific theoretical knowledge of music encoding, storage and transposition informed by computer science as a prerequisite for developing a skill to use digital tools. The main contribution of this article is therefore to identify the key theoretical knowledge and digital resources that music teachers should understand in order to successfully develop and utilize their digital competences in the context of classical music teaching. The main principles and practices of music encoding, storage and transposition are identified and explained with reference to relevant academic studies. Based on analysis and systematization, the open-access classical music digital resources

are selected and classified, taking into account the most representative examples.

The available classical music digital resources are classified into two main groups according to their purpose and potential function in music teaching. While the presentation of the principles and practices of digital music encoding, storage and transposition is designed in a linear narrative flow of text, the classification is done by structuring lists of the main categories of digital resources and specific examples within each category, accessible via hyperlinks, considering that this list is exemplary, but by no means final. By writing a text in which the perspectives of linear and structured thinking are equally engaged, we put forward the initial thesis that digital competences in music teaching require both narratives of computer science-based theoretical knowledge about the encoding, storage and transposition of music and knowing of programs and databases as the outputs of these practices, functionalized as concrete digital teaching tools.

Acquiring relevant theoretical knowledge is crucial for music teachers to effectively apply digital competencies in demonstrating their expertise within the specific context of the educational process. Availability of digital resources appears as an additional category to theoretical knowledge that drives the ability of music teachers to apply digital technologies in the music education process and develop a necessary skill. The possession of specific knowledge and skills is necessary to form a positive attitude as the third element of competences alongside knowledge and skills. The presentation of knowledge and tools as key principles, practices and examples of music encoding programs and databases is intended to help and encourage teachers to understand the mechanisms of technologically mediated knowledge transfer, successfully navigate the multitude of resources available and select those that meet the specific objectives and outcomes of each subject and lesson.

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