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Green and/or digital transition in music education? Analysis of European policy papers and competence frameworks

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Abstract

This article critically analyzes the interplay of digitalization and sustainability in European policy papers and competence frameworks, with a focus on implications for music education. Drawing on a comparative document analysis of key frameworks such as DigComp 2.2 and GreenComp, as well as policy documents like the European Green Deal and the Digital Education Action Plan, we uncover a significant gap between high-level ambitions for "twin transitions" and their practical integration in educational contexts. The competence frameworks show minimal links to music and struggle to address contradictions, such as the environmental costs of digital technologies versus their proposed benefits. By exploring sustainable practices like low-tech music-making and ethical AI use, this analysis calls for a curriculum that critically aligns music education with broader sustainability and digitalization goals, positioning it as a transformative force in addressing climate challenges.

Introduction

Policy papers are used by the European Union as an important instrument to communicate the key strategies for social, economic and cultural development within Europe and shaping the future. Even though the papers are in most cases not legally binding, they have an impact on many levels: They provide guidance to member states when developing national strategies as well as curricula on all levels of education and are important references for the development of funding strategies. At a global level, these documents are embedded in frameworks such as the OECD Learning Framework 2030 (Organisation for Economic Co-operation and Development, 2018) and the United Nations (2015) Sustainable Development Goals. In recent years, key documents that reflect the cornerstones of the European Union's development work have also been regularly published dealing with education. Strategies communicated on a policy level are usually made more specific in relation to different content areas in a second step and used to develop competence frameworks or strategic recommendations for action.

When applying for an Erasmus+ Teacher Academy in music education we referred to key topics from relevant framework documents like digitalization, sustainability, participation and creativity. Referring to this, our project *TEAM – Teacher Education Academy for Music.*

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Future-Making, Mobility and Networking in Europe addresses the topics of democracy education, digital music practices and sustainability from the perspective of our subject. The fact that central thematic areas like digitalization and sustainability are always considered together at the level of EU policy work and have an impact on the most diverse areas of European work is symbolically shown by a monument that we discovered at a project meeting in Dublin (Fig. 1). It reminds us that Dublin 2024 is the European Capital of Smart Tourism. On the back, the thematic areas of accessibility, cultural heritage & creativity, digitalization and sustainability are shown closely intertwined.

Figure 1. Dublin 2024 – European capital of smart tourism: digitalization, sustainability, accessibility, cultural heritage & creativity (photos by authors)

When developing learning offers for music education in our project, we similarly aim to consider the different thematic dimensions of digitalization, sustainability and democratic education in context. During our work, however, we discovered that it is not always easy to reconcile the logics and norms inherent in the subject areas addressed. In short, we discovered that what works well together on a policy level, is not always coherent on the concrete content level. This led us to examining the logics of policy papers and the different competency frameworks for the education sector in more detail. In this article, we present our findings related to the topics of sustainability and digitalization. Our document analysis reveals that these topics are closely linked at the level of the policy papers. In contrast to this, topic-specific documents are underpinned by conflicting logics and norms, while systematic links and cross-references between sustainability and digitalization are rare. Further, we will illustrate the role of music in the examined documents, in order to identify subject-specific references.

Method

To address these questions, we conducted a qualitative comparative document analysis (Bowen, 2009). We selected policy documents published on the European Union website between 2019 and 2024 that address connections between sustainability, digitalization and education and that are referenced in other European policy papers. Following these criteria, we identified the following central policy paper (chronological order):

(1) European Green Deal (European Commission, 2019)

(2) Digital Education Action Plan 2021-2027 (European Commission, 2020a)

(3) Shaping Europe's digital future (European Commission, 2020b)

(4) Council Resolution on a strategic framework for European cooperation in education and training towards the European Education Area and beyond (2021-2030) 2021/C 66/01 (Council of the European Union, 2021)

(5) Council Recommendations on learning for the green transition and sustainable development (Council of the European Union, 2022)

(6) Digital Decade (European Commission, 2023, 2024a)

In order to be able to examine the level of topic-specific documents that are designed as concrete recommendations for action in educational practice, we included the following competence frameworks specifically published on digitalization and sustainability by the European Commission in our sample:

(1) DigComp (Ferrari, 2013)

(2) DigComp 2.0 (Vuorikari et al., 2016)

(3) DigCompEdu (Redecker & Punie, 2017)

(4) DigComp 2.1 (Carretero et al., 2017)

(5) SELFIEforTEACHERS (European Commission, 2024c)

(6) DigComp 2.2 (Vuorikari et al., 2022)

(7) GreenComp (Bianchi et al., 2022)

The DigComp frameworks address digital competences of European citizens, while DigCompEdu focusses on the educational sector by describing digital competences of educators. We also analyzed SELFIEforTEACHERS. This self-reflection tool for teachers derived from DigCompEdu is designed to help educators to reflect on and develop their digital competences. We complete the sample by adding GreenComp. This is currently the only European competence framework focused on sustainability. Both, DigComp and GreenComp are "the result of consensus building based on a mixed method research process" (Bianchi et al., 2022, p. 10) with experts and stakeholders (Ferrari, 2012; Janssen & Stoyanov, 2012).

We analyzed this sample using the following keywords, that we identified as relevant in the context of our research questions: "digital", "green", "sustainable", "sustainability". Later we extended the keywords by "environment", "values", "energy", "future/s", "participation" and "climate", as these keywords were often used in relevant passages we could identify in our first search results. The keywords "culture", "creative" and "music" helped us to find relevant passages with regard to our subject specific research interests. In this step we focussed on DigComp 2.2 and GreenComp as a subsample as we were able to work out in our first analysis that these documents are considered representative with regard to the presentation of the topics of digitalization and sustainability in European framework documents.

In the passages we identified by the keyword search we examined the argumentative logic, goals, norms and implicit patterns underpinning the argumentations. This analysis was informed by the procedural steps of the documentary method (Bohnsack, 2021). Further, we analyzed connections between the themes of sustainability, digitalization and music. Like this we could identify hidden contradictions between the topics examined. Since we used a

qualitative-reconstructive approach in our study, we largely refrained from quantifying the results. Nevertheless, in some places we referred to how often we were able to find a search term, especially if this could document the low presence of the associated topic area.

Green and Digital Transitions in European Policy Papers

In 2006, digital competences and sustainability both were mentioned in the Recommendation of the European Parliament on key competences for lifelong learning (European Parliament & Council of the European Union, 2006). Since Ursula von der Leyen became President of the European Commission and the 'new strategic agenda for the EU 2019-2024' was implemented by the Council of the European Union (2019), the topics of "digital transformation" and "embracing the changes brought about by the green transition, technological evolution and globalisation while making sure no-one is left behind" (Council of the European Union, 2019, p. 4, 5) are among the key priorities. Our analysis of policy papers shows that this central narrative of 'The Green and Digital Transitions' is very central in the selected policy papers in our data.

For bringing together digitalization and sustainability at European level the 'European Green Deal' is a central starting point. It mentions the "twin challenge of the green and the digital transformation" (European Commission, 2019, p. 7) and continues that "[d]igital technologies are a critical enabler for attaining the sustainability goals of the Green deal in many different sectors" (European Commission, 2019, p. 9). Accordingly, the Council of the European Union (2022) sets the same frame "towards inclusive green and digital transitions for future resilience and prosperity" (p. 2). Complementary, the paper 'Shaping Europe's digital future' refers to the overarching Sustainable Development Goals (SDGs) of the United Nations (2015): "Beyond the energy efficiency requirements of Ecodesign, ICT equipment must become fully circular designed to last longer, to be properly maintained, to contain recycled material and to be easily dismantled and recycled" (European Commission, 2020b, p. 12).

A central education-specific policy paper is the 'Digital Education Action Plan 2021-2027'. Published in 2020, it states that "[d]igital education and skills should also take into account environmental and climate impacts of the development and use of digital equipment and services" (European Commission, 2020a, p. 9; see also European Commission, 2021a). In the 'European Education Area', sustainable economic prosperity, the green and digital transitions, and employability" (Council of the European Union, 2021, p. 3) are a central goal as well. Accordingly, one of its five strategic priorities is "supporting the green and digital transitions in and through education and training" and it also provides a normative justification:

> The green and digital transitions are the core focus of the Union's agenda for the next decade. Both the transition to an environmentally sustainable, circular and climate-neutral economy as well as a more digital world, will have significant social, economic and employment impacts. Without ensuring that all citizens obtain the necessary knowledge, competences, skills and attitudes to cope with these changes, a socially just transformation of the EU will be impossible (Council of the European Union, 2021, p. 7).

Building on this, the 'Council Recommendations on learning for the green transition and sustainable development' "underscores the importance of digital technologies as powerful enablers for the green transition whilst, at the same time, facilitating a move towards sustainable behaviour in both the development and use of digital products" (Council of the

European Union, 2022, p. 2). Recent general policy papers transport a rather optimistic view of the future in the 'Digital Decade' (European Commission, 2023). Nevertheless, environmental concerns are addressed in certain formulations of smart greening. Despite highlighting the potential for reducing the environmental footprint following the digital transformation, it also mentions the challenges in energy efficiency, device recycling, and sustainable innovation to mitigate its environmental impact of the rising global electricity consumption (European Commission, 2024a, p. 19).

Overall, our analysis shows that the selected European policy papers always consider digitalization and sustainability together as the green and digital transition. Problematic interrelationships such as the growing demand for energy and the consumption of resources are mentioned in several places.

Digital and Green Competence-Frameworks

Let us now turn to the more concrete formulation of competences to examine how these required 'green and digital transitions' are transferred from the European policy level to application. DigComp, DigComp 2.2, DigCompEDU and SELFIEforTEACHERS attempt to collect digital competences, whereas GreenComp focuses on competences in the area of sustainability. This observation alone shows that the two topics of digitalization and sustainability are treated separately at this level, whereas at the level of the policy papers both topics were presented as part of a coherent strategy.

Sustainability in DigComp

In 2013, the DigComp was published, with the aim of proposing "a framework for digital competence for all citizens" (Ferrari, 2013, p. 4). The project outcomes included a self-assessment grid and a detailed framework for digital competence, covering five areas: information, communication, content creation, safety, and problem-solving. Each of the 21 competences is detailed with definitions, proficiency levels, related knowledge, skills, and attitudes, as well as practical examples for learning and employment contexts. Our keyword search led us to passage '4.4 protecting the environment' (Ferrari, 2013, p. 31, see Fig. 2) that is relevant for our study.

Here, three proficiency levels (Foundation, Intermediate, and Advanced) are outlined for understanding and mitigating the environmental impact of ICT (Information and Communication Technology), ranging from basic energy-saving actions to informed decision-making on technology use and its effects. It emphasizes knowledge, skills, and attitudes that enable individuals to evaluate digital tools' efficiency, extend device lifecycles, and adopt a sustainable approach to technology use.

DigComp's formulation in the subsequent dimension 5 states the following learning outcome: "I tend to opt for a technological solution rather than a non-technological one when I see that the digital choice has less impact on the planet" (Ferrari, 2013, p. 32). A critical green examination of digital media within DigComp would be possible starting from this point. Nevertheless, we have to recognise that this fundamental question of whether digital media should be used at all should not belong in a small sub-chapter if sustainability was really taken seriously. On top of this, it is almost impossible to answer this question even for the simplest applications. If I want to make music with a tablet or a glockenspiel, how can a person make a well-founded purchase decision with regard to the impact on the planet or recycling options?

Dimension 1 Name of area	Safety		
Dimension 2 Competence title and description	**4.4 Protecting the environment** To be aware of the impact of ICT on the environment		
Dimension 3 Proficiency levels	A - Foundation	B- Intermediate	C- Advanced
	I take basic measures to save energy.	I understand the positive and negative aspects of the use of technology on the environment.	I have an informed stance on the impact of technologies on everyday life, online consumption, and the environment.
Dimension 4 Knowledge examples	Can determine if appropriate and safe digital means are available, that are efficient and cost-effective in comparison with other means		
	Has a comprehensive mental map of how the online world works.		
	Understands the technologies s/he is using at a level that is sufficient to underpin good purchasing decisions, e.g., about devices or Internet service providers		
	Understands the environmental impact of computers and electronic devices and how s/he can make them last longer by recycling parts of it (such as changing hard disks)		
Skills examples	Is able to use digital services without being completely dependent on them (or: helpless without)		
	Knows how to use digital equipment cost-efficiently and also time-efficiently.		
Attitude examples	Has a positive but realistic attitude towards the benefits and risks associated with information technologies		
	Has understood that the digital environment we are facing can make things better or worse - it all depends on how we are using it and what rules we find for it		
	Is aware of environmental issues related to the use of digital technologies.		

Figure 2. rotecting the environment" in DigComp (Ferrari, 2013, p. 31)

Sustainability in updated versions of DigComp (2.0, 2.1, 2.2)

In 2016, DigComp 2.0 (Vuorikari et al., 2016) was published as an update. With regard to our research focus, one minor change happened in the new chapter "4.4 Protecting the environment - To be aware of the environmental impact of digital technologies and their use" (Vuorikari et al., 2016, pp. 9, 32). Divided into 6 proficiency levels, the DigComp 2.1 (Carretero et al., 2017) then ranges from the competence to "recognise simple environmental impacts of digital technologies and their use" (Carretero et al., 2017, p. 39) to advanced levels of choosing "the most appropriate solutions to protect the environment from the impact of digital technologies and their use"(Carretero et al., 2017, p. 39).

In 2022, the updated version DigComp 2.2 (Vuorikari et al., 2022) was published. In its introduction you can read: "There is also an increasing need to address the green and sustainability aspects of interacting with digital technologies" (Vuorikari et al., 2022, p. 1). Looking into the document, the updates are identified by a red 'Add-on' symbol. [E]nvironmental sustainability concerns (e.g. resources consumed by ICT)" (Vuorikari et al., 2022, p. 5) are among "[m]ore than 250 examples highlight[ing] new and emerging themes that have arisen since the last update" (Vuorikari et al., 2022, p. 5). And this time, the double-page on protecting the environment was given a big makeover. DigComp 2.2's competences 203-216 (Vuorikari et al., 2022, p. 42) take a critical stance on:

- "'green' behaviours to follow when buying digital devices, e.g. choose products with less energy consumption during use and stand-by, less polluting (products easier to dismantle and recycle) and less toxic (limited use of substances harmful to the environment and health) (206)"

- the "carbon footprint of transport, generation of waste (207)"

- the trade-off between energy efficiency (208) achieved through artificial intelligence on the one hand and the AI energy consumption on the other hand "which can also have a high environmental impact. (AI) (209)"

- "ethical consequences of AI systems throughout their life-cycle: they include both the environmental impact (environmental consequences of the production of digital devices and services) and societal impact, e.g. platformisation of work and algorithmic management that may repress workers' privacy or rights; the use of low-cost labour for labelling images to train AI systems (AI)."

Competence 210 aims in a similar direction: "Knows how to apply efficient low-tech strategies for protecting the environment, e.g. shutting down devices and switching off Wi-fi, not printing out documents, repair and replace component [sic!] to avoid the unnecessary replacement of digital devices" (Vuorikari et al., 2022, p. 42). This example on low-tech strategies shows the contradiction caused by the add-on. Low-tech as a movement claims principles like back to basics, repair it locally, make technology your own and use less tech (e.g. The Low-tech Lab, 2024). These approaches are fundamentally different compared to the techno-positive argumentation we identified in the other parts of DigComp 2.2 and the corresponding self-reflection tool. In the SELFIEforTEACHERS for example, it is suggested to level up from identifying to selecting, proposing, and varying all the way to creating with digital media and tools. This shows that, on an implicit level, the main goal is to increase the use of technology. "Less" does not really seem to be an option, as the word only shows up in competence 206 in order to "choose products with less energy consumption […] less polluting and less toxic" (Vuorikari et al., 2022, p. 42). This is why the strong low-tech-and-less arguments against digital technology in this new section of DigComp 2.2 stand out somewhat surprisingly. However, since they don't appear anywhere else, sustainability does not emerge as a continuous or integrated theme in DigComp 2.2—it remains an add-on.

Instead of providing strategies to avoid the use of technology or to support sustainability goals we observe a logic that Selwyn (2023) calls "techno-solutionism". Examples for this are the mentioned use cases for protecting the environment. They do not focus on the media reflection or aim for a responsible usage, but remain only on media production, e.g."I can create an illustrated video which answers questions on the sustainable use of digital devices in organisations of my sector, to be shared on Twitter" or "I can create a new eBook to answer questions on the sustainable use of digital devices" (Vuorikari et al., 2022, p. 42). In addition our analysis shows that the keyword 'values' are mostly economic values and not values in the sense of justice or solidarity. Further, ethical issues only really play a role in the context of AI.

Sustainability in DigCompEDU and SELFIEforTEACHERS

As we have shown, there are not many but some references to the topic of sustainability in the general digital competence frameworks for citizens. As a supplement to DigComp the competence framework specifically for educators DigCompEDU (Redecker & Punie, 2017) was published between the various DigComp updates. In this framework environmental questions as they were raised in DigComp and DigComp 2.2 are not addressed. Whenever

'environment' is mentioned, it is almost always about 'digital environment' and not about 'environment' in the sense of the planet, sustainability, recycling or even climate change. The only reference to be found to environment in DigCompEDU is: "To be aware of the environmental impact of digital technologies and their use" (Redecker & Punie, 2017, p. 84). Compared to the passage on decision-making for or against the use of digital media for environmental reasons in DigComp the reformulation to 'awareness' is weaker. Accordingly, sustainability is again completely absent in the subsequent progression formulation. One reason might be that digitalization in DigCompEDU is primarily understood as digital technology with tools and content, devices, resources and data (see Fig. 3). This does not take into account social and ecological aspects, such as mentioning the use of non-digital technologies.
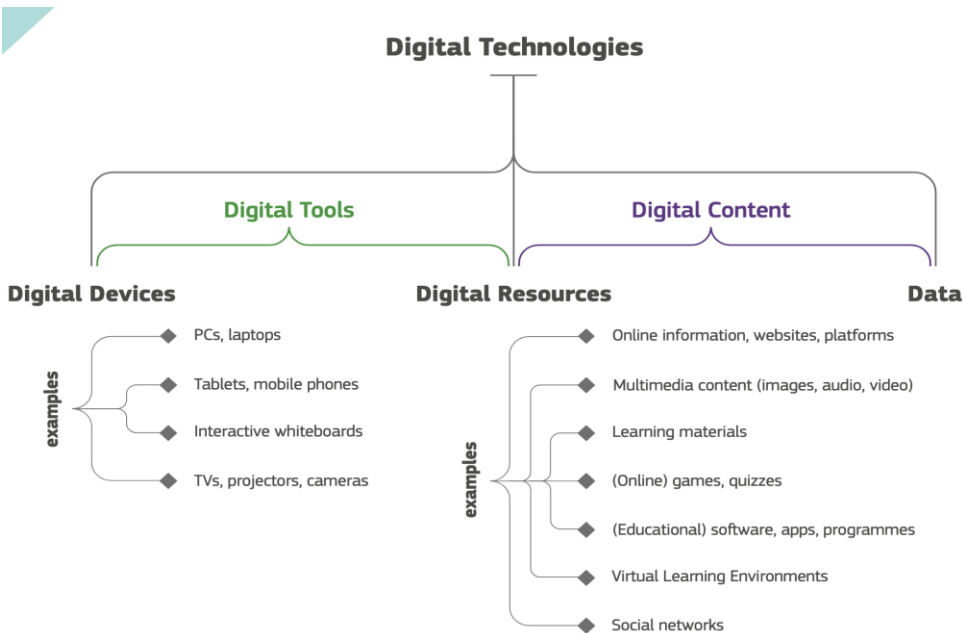
Figure 3. Digital technologies in DigCompEDU (Redecker & Punie, 2017, p. 88)

The reflection questionnaire SELFIEforTEACHERS (European Commission, 2024c), which is based on DigCompEDU, was launched in 2021 and is intended to give teachers the opportunity to assess their expertise in dealing with digital media. The tool implies a "logic of progression [...] in which one can and should work one's way up" (Weich et al., 2020, p. 58, own translation). This 'level-up', with the six levels from newcomer to pioneer already described in DigCompEDU, also reveals another problem. Advanced teachers are those who use more digital media: "Leaders have a consistent and comprehensive approach to using digital technologies to enhance pedagogic and professional practices" (Redecker & Punie, 2017, p. 30). According to this categorisation, a teacher cannot be a leader if he or she uses digital media very little, but in a very environmentally conscious way. Following this logic, only the pioneers "are concerned about the constraints or drawbacks of these practices" (Redecker & Punie, 2017, p. 30). Accordingly, only one question in the SELFIEforTEACHERS exists that could be interpreted in terms of sustainability. It is in the Safety and Wellbeing section, under point 6.4:

> I contribute to create a culture in our setting and its wider community, where the negative and positive uses of digital technologies are openly discussed as well as ways of avoiding risks and threats (e.g. online safety or digital well-being workshops for parents/families, children and staff) (European Commission, 2024c).

Digitalization in GreenComp

GreenComp (Bianchi et al., 2022) is the counterpart to the DigComps in the area of sustainability. The 'European Sustainability Competence Framework' was published in 2022 and so far – other than the sequence of versions of the digital framework – there is only one green competency framework. But the people behind the 'GreenSCENT Competence Framework' are working on a way of revisioning it (Tomassi et al., 2024). GreenComp's authors give education a key role in the green transition: "To protect the health of our planet and our public health, it is crucial to integrate sustainability into our education and training systems" (Bianchi et al., 2022, p. 1). Once again, the starting point is the aforementioned 'European Education Area by 2025' (Council of the European Union, 2021).

How does GreenComp address topics connected to digitalization? Even though the word 'digital' is only mentioned 7 times, GreenComp refers to DigComp in the foreword (Bianchi et al., 2022, p. 1). Following the policy papers, the two sides of the relationship between digital transition and sustainability are reflected: "Teaching approaches can incorporate digital technologies to support people in acquiring competences. At the same time, they must take into account the impact of digital technologies on sustainability" (Bianchi et al., 2022, p. 33). With reference to the Sustainable Development Goal 13 (United Nations, 2015), building a collaborative "community of practice to decide collectively, act collaboratively, and co-create solutions for sustainability" on a "digital platform" (Bianchi et al., 2022 p. 30) is seen as a major advantage of digitalization with regard to sustainability. Particularly noteworthy for our study is that 'digitisation' is explicitly mentioned as a cause for the acceleration of climate change and loss of biodiversity: "Technological change, digitisation, and globalisation have increased our society's complexity and accelerated socioecological problems such as climate change and loss of biodiversity. Environmental challenges are interconnected and interlinked to economic activities and societal lifestyles" (Bianchi et al., 2022, p. 22).

If the digital transformation is to be understood as a central social change, the GreenComp reveals a rather incomplete understanding of this change. Following this path, it becomes clear that the overall focus of the GreenComp lies elsewhere (Fig. 4). GreenComp reflects values, complexity, futures and actions. It reveals structural problems such as the necessity of system change, e.g. "Knows that sustainability problems must be tackled by combining different disciplines, knowledge cultures and divergent views to initiate systemic change" (Bianchi et al., 2022, p. 51) or "Knows that when human demand for resources is driven by greed, indifference and unfettered individualism, this has negative consequences for the environment" (Bianchi et al., 2022, p. 43).

Elsewhere, "tensions between sustainability and consumerism" (Bianchi et al., 2022, p. 21) are emphasised. In contrast to DigComp 2.2, more frequent reference is made to such values. For example, there is an entire competence area on 'Embodying sustainability values'. Another difference can be seen in the topic of future literacies, which play a central role in GreenComp and in the sustainability discourse, while the word 'future' does not appear in DigComp 2.2. In GreenComp it says: "Can envisage alternative futures for sustainability that are grounded in science, creativity and values for sustainability" (Bianchi et al., 2022, p. 49).

Figure 4. Visual representation of GreenComp (Bianchi et al., 2022, p. 6)

In terms of resource consumption, reference is made to the alternative economic model of the circular economy, that is also mentioned in the Digital Education Action Plan 2021-2027 (European Commission, 2021a, p. 1): "'Reduce, reuse, recycle' is a well known concept for the circular economy" (Bianchi et al., 2022, p. 28). "[D]urability, reusability, upgradability and reparability (SDG 12)" (Bianchi et al., 2022, p. 29) can be read as implicit references to the issue of digital devices and would therefore be criteria for the purchase of them. Here again there is a possible link to DigComp 2.2, where the concept of low-tech is addressed in competence 210 (Vuorikari et al., 2022, p. 42). So overall we conclude that there are references to the discourse on digitalization in the GreenComp, but the connection is only made explicitly a few times.

Music in DigComp 2.2 and GreenComp

What about music? As music educators, we in the TEAM project are interested in what implications can be derived from frameworks to music and to music education practice. So we looked for the contexts in which the term 'music' appears in the two focused documents. And to spoil it already: we found very little music, although a musical note, a microphone and headphone on the cover of DigComp 2.2 (Vuorikari et al., 2022) initially appears to be quite musical (Fig. 5).

Looking into the inside, the word 'music' appears in DigComp 2.2's competences 61, 93, 119, 134, 139, 142 and 149 (Vuorikari et al., 2022) and reveal a fragmented understanding of music and media. They are about content curation in "music playlists" (61), rules for behavior to "using audio headsets instead of loudspeakers when taking calls in public places or listening to music" (93), the creation of content like music with AI (119) and editing or manipulating digital content with AI (134), for instance how to "incorporate AI generated melodies in one's own musical composition". Competencies 139, 142 and 149 address legal awareness and the copyright issues of music downloads or sharing. In other words, DigComp 2.2 does not address the cultural and creative aspects of music practices. For example, composing music in a creative way or music and media reflection are not mentioned.

Figure 5. Cover of DigComp 2.2 (Vuorikari et al., 2022)

In the GreenComp, the term 'music' does not appear at all. Indirectly, music can be seen as a contribution to "cultural and social changes, as well as behavioural shifts and institutional reforms" (Bianchi et al., 2022, p. 28). And in the broadest sense, the following phrase can be read as a mandate for alternative and artistic-musical approaches to the topic of sustainability: "can establish a transdisciplinary approach to framing current and potential sustainability challenges" (Bianchi et al., 2022, p. 25). These findings, that DigComp 2.2 has a very narrow and content-focussed understanding of music and GreenComp only refers indirectly to music and culture, make it necessary to develop possible approaches for music education practice in the following discussion and outlook.

Discussion

European policy papers call for a digital and green 'twin transition'. To establish a solid baseline, this premise must be subjected to critical scrutiny. Despite the debate between increasing efficiency through digitalization and increasing energy and resource consumption like in the 'Digital Decade' report, the central narrative of the European Commission and the Council remains that both developments point positively to a digital and green future within economic growth. The problem that such political representations hardly address fundamental contradictions has already been criticized in the discourse. Lange and Santarius (2023) have shown that the coexistence of the two strategies can be problematic if the topics are not structurally thought of together (see also Santarius et al., 2023):

> It appears as if digital policymaking and sustainability policymaking take place on different planets. For instance, the current European Union's two major policy packages are the 'European Green Deal' and 'Fit for the Digital Age'. But the vast majority of regulatory initiatives coming from either package do not address the opportunities and risks of digital technologies for sustainability (Lange & Santarius, 2023, p. 12).

Further – as many fundamental assumptions of digitalization contradict sustainability – Lange and Santarius discussed a 'digital reset'. They claim that "if economic growth is the overriding goal of digital governance, outcomes will likely run counter to sustainability", further criticize "linear production models", "unsustainable consumption habits", and "rebound effects that eat up savings potential" and conclude that "[d]igitalisation must be governed with the aim of eliminating the root causes of unsustainable production and consumption patterns, not just alleviating their symptoms" (Lange & Santarius, 2023, p. 12). The Add-on idea of DigComp 2.2, contradicts this view. Sætra (2023) asks just as pointedly "whether technology can be used to fix the very problems caused by technology" (p. 5) and Selwyn (2023) states that "[t]he continued excessive application of digital technology in any context – education included – makes little sense in terms of environmental sustainability" (p. 79). Nevertheless, digital progress is always framed as part of the solution in the European policy papers, even though this "techno-solutionism is most likely to perpetuate (and perhaps intensify) sustainability harms" (Selwyn, 2023, p. 78). The special issue of the Journal of Environmental Education "Digital technologies and environmental education" edited by Lowan-Trudeau (2023) addresses precisely this point.

We showed that there are few links between the digital and green competence frameworks and the required systematic interlinking of both topics is missing. Overall, the tensions and contradictions between digitalization and sustainability, which are inherent in the discourses (Göpl, 2023), are visible between and within the competence frameworks. The separation of these topics is further amplified by the communication and implementation strategies of the European Commission. Highlighted as focus topics, digitalization and sustainability are communicated separately on the "Green Education" and "Digital education" (European Commission, 2024d, 2024e) websites of the European Education Area. Further, communities of practice are being established: "Education for Climate" (European Commission, 2024b) and the "European Digital Education Hub" (European Commission, 2024f) are platforms where webinars, surveys and information on the respective topics are shared and discussed. The European Digital Education Hub is organised via Microsoft Teams, an EU login is required for 'Education for Climate' and Webex is used. Bridging formats that address digitalization and sustainability in context are missing. One of the rare exception is the event '2021 Digital Education Hackathon: Digital education for a sustainable world', which linked the two topics in a concrete way (European Commission, 2021b).

Our research further demonstrated that both DigCompEDU and DigComp 2.2 offer a limited understanding of media and therefore also of music. DigCompEDU has already been criticized. In particular, the media reflection is identified as insufficient: "The relationship between materiality and content, which is so important for media reflection, is [...] systematically conceptually 'blackballed'" (Weich et al., 2020, p. 57). Because "media reflection is rudimentary at best" (Weich et al., 2020, p. 58), they call for "a media didactics that is actually based on media culture studies, which does not demand 'Use digital technology for XY' from the outset, but rather builds on understanding the media-technical and media-cultural

prerequisites and making pedagogical, didactic and methodological decisions based on this" (p. 60). In this sense, the use and understanding of media should also be critically analyzed in terms of sustainability before and while deciding which, when and how media should be used in educational contexts. These green questions are blackboxed in DigCompEDU.

Swertz (2019) supports DigComp 2.2's reorganisation with regard to inclusion as a "pleasingly clear positioning" (p. 7), but criticizes that "the data show that the dimensions of creative media design, receptive media use and ethics do not appear in the DigComp 2.2 model" (p. 15–16). This insufficient comprehension of the media reinforces our conclusion that the inquiries pertaining to sustainability, which inherently encompass ethical considerations, are absent from DigComp 2.2, despite their central necessity. The only exceptions to this are ethical questions about AI, which are raised.

With regard to sustainability, we showed how DigComp 2.2 added several critical aspects at the interplay of digital and green translation. But the additional competences only play a small part and are not structurally embedded. Relevant critical competences stand in obvious contrast to the techno-positive rest of the framework. If these competences like the one on low-tech were to be considered important, then a fundamental interlocking of sustainability and digitalization would have to be tackled as a whole. At the same time, the fact that the concept of 'low-tech' is at all addressed in one DigComp 2.2 competence formulation, as is the problematic increase in energy consumption due to AI, can be seen as an indication that the two competence models could at least be partly interlinked. GreenComp's durability, reusability, upgradability and reparability could represent this bridge. And yet, we were able to show that these weak connections are almost completely absent in the DigCompEDU and SELFIEforTEACHERS versions for educators.

We also mentioned the focus on economic values which is also evident in the cooperation partners. The EdTech involvement in DigComp 2.2 can be seen in Microsoft's commitment to the 'All digital weeks' and in the fact that the European Digital Education Hub online community is organised via Microsoft's Teams tool. Microsoft is of course not the company trying to present themselves as green and sustainable, but at the same time they are not managing to keep up with the rapidly growing hunger for energy, mainly due to artificial intelligence, with the carbon reduction goals they have set themselves (Smith, 2024). With a critical eye, such a lobbying connection between the European Commission, the education system and technology companies must be seen as problematic. Using the example of the topic of sustainability, it becomes clear at this point what Geiss et al. (2023) generally criticise about the logic underlying the development of educational recommendations for action:

> As the history of the European debates and initiatives regarding the introduction of new information technology into education indicates, there is certainly no easy way to deduct skill demands from technological development alone, as the education for a digital society is necessarily intertwined with contested and value-laden ideas of what such a society entails and how it is organized. Moreover, the fast pace of technological change necessitates a constant re-evaluation of temporary conclusions. As such, it seems impossible to pin down a persistent set of skills that a future European workforce or citizenry requires (Geiss et al., 2023, p. 211 f.)

The development of educational recommendations for action must therefore not be based solely on technological and economic guiding principles, but must consider the use of technology from an overall social perspective. In such an approach, the question of

sustainability aspects must be placed at the centre of the conceptual design. Selwyn (2024) illustrates this referring to the example of artificial intelligence in education: "It makes good sense for educators to try to disconnect themselves from the apparent imperatives of AI-driven educational 'transformation', and instead work to slow down discussions around AI and education, and introduce an element of reflection and nuance" (Selwyn, 2024, p. 12).

Our analysis of the green competence framework reveals that while GreenComp acknowledges the complex relationship between digitalization and sustainability, it does not explicitly address this interplay in depth. The framework focuses on the importance of reducing, reusing, and recycling, as well as considering different future scenarios and values. This means that GreenComp does not adequately reflect the fundamental developments in the field of digitalization. In our opinion, the questions raised are too big to be integrated in just a few competence formulations or phrases and not structurally.

Another point of our criticism is GreenComp's placement in an economic growth norm with reference to the SDGs, the Sustainable Development Goals by the United Nations (2015). They are the "lingua franca" (Sætra, 2023, p. 5) in the field of sustainability, but not without problems, as "the goals themselves are interrelated and even partially contradictory" (Sætra, 2023, p. 5). Tomassi et al. (2024) bring in yet another level: "Despite the urgent need to address climate change, the Capitalocene system continues to prioritize profit over sustainability, and the interests of the wealthy and powerful over the needs of the planet and its inhabitants" (p. 166). This is one of the reasons why Selwyn (2023) writes about "Digital degrowth" along slow and low-impact lines.

When searching for connections and differences on a more general level, we would like to emphasise that both competence models DigComp 2.2 and GreenComp underline "problem solving" and "critical thinking" as an answer to complexity. This could also be seen as a starting point for further connected development of the frameworks. But there is also a deep divide: Our research shows that digitalization is not based on values, but instead the digital frameworks talk about economic values. In contrast, GreenComp is deeply connected to values. In general, it can be stated that GreenComp tends to pursue an individual to collective-political approach, while DigCompEdu and DigComp 2.2 opt for an individualistic maximal collaborative approach.

Further development of the frameworks is taking place, for example, by Tomassi et al. (2024) who are trying to increase the accessibility of GreenComp with innovative tools like knowledge graphs. As part of the GreenSCENT project they have investigated the links and strength of connections within the frameworks to develop a new competence framework. It remains to be seen whether such a data-based revision will depict the digital and green transitions differently. So far, the term 'digital' is hardly reflected in the two published articles. We were able to show the problem of the lack of cross-references between the two sides of digital and sustainable competence models – not quite on 'different planets', but very little intertwined. The question for a teacher in the classroom remains: How do I deal with trying to take into account both the digital and green competence models, but being faced with contradictions and missing links?

Outlook for Music Education

This question is also relevant in the music classroom. We have shown that there are hardly any references to music in the analyzed framework documents. GreenComp has only implicit connections to music while DigComp 2.2 shows a very limited understanding of what musical practice looks like and how music can be approached beyond 'content'. This means that music teachers find few guidelines with regard to musical practice in the digital age and also with regard to sustainability. Consequently, they are faced with complex questions, e.g.: If I use resource- and energy-consuming tablets to create a song about climate change – is that sustainable music education? If I pursue low-tech approaches and only want to make music with used technologies – are we moving in the direction of maker music education (Treß, 2024)? To put it bluntly: Can I make sustainable music lessons with the iPad?

The topic of artificial intelligence is also controversial in music education. For example, new possibilities for creating and manipulating sound are set against the enormous consumption of energy and resources. This raises the question of the extent to which generative music AI should be used to create music in educational contexts at all, as its use is associated with considerable harmful climate-relevant side-effects as well as other ethical and social consequences (see also UNESCO, 2022). This shows that a concrete implementation of the green and/or digital transitions will remain challenging both socially and educationally. Following the discourse in music education reveals a similar picture: Although there is an intense discourse on digitalization and technology in music education (Buchborn & Treß, 2023; Ruthmann & Mantie, 2017) and a growing number of publications in the field of "the emerging ecological shift" (Barrett & Westerlund, 2023, p. 15; see also Bates, 2024; Eusterbrock, 2022; Malmberg, 2023; Shevock, 2017), there have been few links between the two areas so far. Buchborn et al. (2022) asked: "How can we address climate change as a core task of music education practices alongside diversity, digitalization and democracy?" (p. 277). They put in a set of provocations on how "(re-)configuring music education as future-making for sustainability" (p. 277) could look like.

To name a few possible approaches for music education: sustainable and digital music education can integrate interdisciplinary projects, such as creating soundscapes (Schafer, 1977/2006) to highlight environmental issues, blending sustainability and digital competencies. Maker music education, like crafting instruments from recycled materials, promotes creativity while reducing environmental impact, with digital tools used selectively and critically (Buchborn & Treß, 2023; Treß, 2024). In context of artificial intelligence (Cheng, 2025), music educators should also address the ethical and environmental implications of AI, fostering for instance critical engagement with sound creation. Moreover, a values-driven curriculum can inspire students to compose and perform music that imagines sustainable futures and reflects on societal challenges, making music a powerful tool for change (Christophersen et al., 2023). Another potential approach to engaging in discourse with individuals on these matters is a technosceptical perspective informed by values, as exemplified by the "Civics of Technology" initiative (Heath et al., 2024). To illustrate, their "Technoskepticism Iceberg Framework" (Pleasants et al., 2023, p. 503) provides a means of undertaking a critical examination of the technical, psychosocial, and political dimensions while also considering the systems and values that lie beneath the surface.

However, the initiative also underscores the challenges associated with integrating this approach in educational settings, given the pervasive digital optimism and environmental solutionism in contemporary educational practices. These approaches could be integrated

with a postdigital music education (Clements, 2018) that aims to consider the various aspects of the green and digital transitions as a unified whole, in line with Selwyn et al.'s (2020) call for 'critical educational technology scholarship' (p. 2). The analysed frameworks that should guide citizens as well as teachers to develop competences in both fields seem not to be helpful in supporting such an integrative transformation process in music education – especially because of the limited concepts of digitalization and music that underpin these documents. We experience these limitations when we use DigComp, DigCompEdu as well as GreenComp as an orientation to design learning offers for school music education, music teacher education and continuous music teacher education. Furthermore, the limited concept of music as well as the weak connections to music practices requires teachers to make great efforts to adapt when they have to interpret the generic competence formulations in a subject-specific way, relate them to musical contents as well as to the musical lifeworlds of learners. In short, it is a long way from competence frameworks to concrete action in the music classroom. Therefore, policymakers should critically examine the contradictions of the twin transition that have only been hinted at here and use this as a basis for making meaningful connections between digitalization and sustainability in future framework documents in music education. At the same time, music educators should address the questions we have raised in lessons and seminars and discuss them with young people.

Our analysis is limited by the selection of documents examined and to the European context. Future research should investigate the tensions between digital and green music education in other regions, in national curricula and in practice. Therefore, music education researchers should examine how digitalization projects and approaches are compatible with sustainability in music lessons or music studies, but also how green music projects can meaningfully take the (post-)digital transformation into account. Our study advocates for a curriculum that reimagines music education as a critical and creative practice, integrating sustainability and digitalization to empower students as active contributors to addressing environmental challenges.

Declarations

Ethics approval and consent to participate: This research did not involve human subjects.

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