

# Electroacoustic Music Learning Experience Through AI-based Digital Installations: ARTECOM, an ongoing Project dedicated to Teenagers

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**Abstract.** Advancements in digital technologies based on Artificial Intelligence (AI) have made music a constant presence in teenagers' lives, providing them with a means of creative expression and personality shaping. Among the most significant musical activities for promoting teenagers' well-being is the ability to actively create and modify musical tracks, particularly in the field of electroacoustic music, which integrates both acoustic and electronic sounds. However, current AI-based digital technologies for electroacoustic music creation often lack dedicated learning paths, and they are targeted only at experts, limiting their accessibility. The ARTECOM project was conceived to address these issues, aiming to develop AI-based digital installations in strategic urban locations to encourage even non-expert teenagers, especially those facing economic and social barriers to art access, to engage in electroacoustic music creation. This paper presents the initial steps of the project, including a preliminary study on profiling the target participants and their context of use.

**Keywords:** Artificial Intelligence, Big Five Theory, Electroacoustic Music, Inclusivity, Personality, Technology Enhancing Learning, Teenagers.

## 1 Introduction and State of the Art

Music has always been a powerful way to promote well-being and the development of cognitive and emotional skills [6, 9] such as executive control, attention, emotion regulation, and empathy [14, 38]. Beyond passive listening and formal instruction, music creation activities play a key role in stimulating several cognitive abilities and active engagement [21, 41]. In this regard, the beneficial role of music is strong, especially during teenage a critical period for development, characterized by physical,

cognitive, and brain changes [6, 9, 11]. Teenagers experience a brain *imbalance* due to the delayed maturation of the prefrontal cortex, responsible for self-regulation and executive function, compared to limbic structures involved in emotion and reward processing [6, 43]. This *imbalance* contributes to typical adolescent behaviours, where emotions arise intensely while the still-developing capacity for self-regulation struggles to modulate them [6,9]. In this context, music, especially music creation, has always played a key role in modulating cognitive abilities influenced by these brain areas, fostering a *balanced interplay* between emotions, creativity, self-regulation, and executive functions [11,43].

Among the different musical genres, the literature suggests that electroacoustic music, despite it being a “*niche*” genre, due to its unique characteristics, is particularly powerful in shaping personality, stimulating creativity, and evoking emotions in teenagers [7, 18, 25]. Specifically, electroacoustic music refers to a genre that blends electronic sound generation and manipulation with acoustic (or recorded) sound sources [44]. It emerged in the mid-20th century with the development of recording technologies and synthesizers. This genre encompasses different styles, including *musique concrète*, acousmatic music, live electronics, and soundscape creation, generally dedicated to domain experts [25, 44].

However, today, the influence of electroacoustic music creation, even for teenagers who do not have an established musical background, has never been more pronounced, largely due to advancements in digital technologies, particularly Artificial Intelligence (AI) applications. These technological innovations have reshaped the way teenagers interact with music, providing them with unprecedented avenues for both creativity and personality expression [19, 26, 47]. AI-based digital technologies have facilitated the development of electroacoustic music creation applications, utilizing models trained on extensive musical datasets to generate harmonically and rhythmically structured tracks [47, 49]. More importantly, these AI-based digital technologies have significantly enhanced accessibility [41], enabling teenagers to create, edit, and share their creations [49]. Such applications do more than suggest chord progressions and melodies; they function as collaborative creative tools, offering inspiration and guidance [1] while also promoting sound experimentation, creativity, and divergent thinking, ultimately supporting personality expression [15, 19, 22, 30, 36, 40]. Research highlights the link between electroacoustic music creation and personality traits: extroversion and open-mindedness stimulate exploration, whereas introversion may require more structured learning support [5]. According to Flannery and Woolhouse [20], for example, there is a link between personality traits and music-related acoustic features, finding that preferences for certain acoustic characteristics are linked to specific personality traits of the established personality theory known as the Big Five [29]. For instance, *dynamics* were associated with openness and extraversion; *mode* with conscientiousness and extraversion; *register* with extraversion and neuroticism; and *tempo* with conscientiousness, extraversion, and neuroticism. These findings suggest that the predominance of the same personality traits may be drawn to specific acoustic elements, which could influence their creative choices in electroacoustic music [20, 50].

Overall, this evidence underscores how learning to create electroacoustic music can strengthen teenagers' personality characteristics, supporting their general well-being [6, 10, 27, 37, 45].

However, while AI-based digital applications for electroacoustic music creation have the potential to enhance cognitive skills, they also pose ethical challenges. In particular, an overreliance on AI-generated content without clear educational value may impede active learning, potentially limiting cognitive engagement rather than promoting it [17, 28, 31, 48].

Despite this evidence, an analysis of the most widely used AI-based digital applications for electroacoustic music creation, as outlined in Table 1, reveals that these applications still exhibit issues that hinder their capacity to promote well-being through active learning.

**Table 1.** Most widely used AI-based digital applications for electroacoustic music creation.

Name	(i) Structured learning pathway	(ii) Targeting specific end users.	(iii) Pricing Models
<i>Audiostellar</i> [3]	Limited	Sound artists, Experimental Composers	Free, Open-source
<i>RAVE</i> [39]	Limited	Researchers, Experimental Composers	Free Open-source
<i>IRCAM Signal Processing Tools</i> [23]	-	Academic Composers, Experimental Composers	Paid (Academic licensing)
<i>Neutone</i> [32]	Limited	Live performers, Sound artists	Free

The first thing the analysis reveals is that electroacoustic all AI-based applications are targeted at music experts or professionals, such as researchers and artists. None of these applications currently are designed for users without basic musical training or lacking music knowledge.

Generally, they offer high degrees of creative and timbral control but also present challenges in terms of accessibility and learning support. Applications such as *Audiostellar* [3] and *Neutone* [32] emphasize real-time manipulation and exploratory workflows but offer no formal guidance, which may limit the involvement of less experienced users. Similarly, *RAVE* [39] offers powerful synthesis capabilities suitable for advanced users, but its technical configuration may be a barrier for non-experts. *IRCAM* signal processing applications [23] offer professional-level control but are limited by fee-based licenses and limited educational resources.

Specifically, three main issues emerge from the analysis:

- (i) None of the applications reviewed provides a comprehensive learning path designed for learning the principles of electroacoustic music. In particular, *Audiostellar* [3], *RAVE* [39], and *Neutone* [32] offer documentation and video tutorials, while *IRCAM* [23] offers occasional workshops, but these materials are often informal or technical and require prior knowledge of audio processing or music technology. This limits the accessibility of applications for beginners without a solid background in the field.

- (ii) These applications are intended exclusively for professional or research use. As a result, they are not easily accessible or usable by non-expert users. Their interfaces and functionalities often assume a certain familiarity with advanced sound manipulation techniques or with Digital Audio Workstation (DAW) environments, which makes them particularly difficult for non-experts to use.
- (iii) Although applications such as *Audiostellar* [3], *RAVE* [39], and *Neutone* [32] are free and open-source, offering wide access to experimental creators, *IRCAM's* signal processing tools [23] follow an academic licensing model. This may limit their use by independent individuals without institutional support. Furthermore, dependency on external environments may introduce additional costs and complexity, indirectly affecting the accessibility of core AI functionalities.

Overall, these issues make such applications unsuitable for non-expert users, such as teenagers who have never received formal music education in creation, especially in electroacoustic music, and cognitively uninspiring, as they do not provide an active learning pathway.

Based on these premises, the ARTECOM project was developed to take a significant step in overcoming these issues, aiming to provide an inclusive electroacoustic musical creation experience for teenagers without a background in the music creation field through AI-based digital installations.

To this end, ARTECOM will achieve the following objectives by the end of the project through the application of Technology-Enhanced Learning (TEL)-oriented User-Centered Design (UCD) methodology (as detailed in Section 2 (Methodology)):

- (i) Design AI-based digital installations for an inclusive electroacoustic musical creation experience, specifically targeting teenagers, even those without a music creation background (age range 14-22), starting from profiling their personality and context of use.
- (ii) Designing a learning path for learning to create electroacoustic music articulated in increasing levels of difficulty, guaranteeing success even for those who have never had a musical education.
- (iii) Ensuring that the final AI-based digital installations are free and accessible to all helps promote inclusiveness and reduce inequalities. To this end, these installations will be strategically placed in key locations across South and Central Italy.

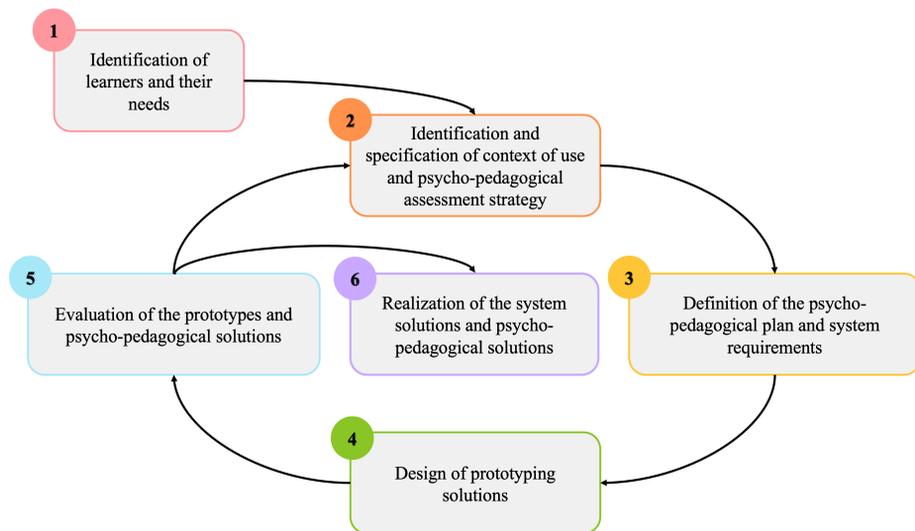
In this paper, preliminary results obtained addressing objective (i), profiling teenagers as end-users and describing their context of use, are presented. It should be noted that the work and preliminary results of experienced electroacoustic music composers will also be presented to support the robustness of what was done for objective (i).

The following paper is structured as follows: Section 2 describes how the TEL-oriented UCD methodology is applied in the ARTECOM project; Section 3 highlights the preliminary outputs, which represent the core of this paper; finally, Section 4 draws the conclusions.

## 2 Methodology

In this section, the TEL-oriented UCD methodology implemented for the realization of the entire ARTECOM project is described. This methodology consists of six closely interrelated steps, as illustrated in Fig. 1. It should be noted that the present paper focuses exclusively on steps 1 and 2. Therefore, these steps will be described in greater detail, and the preliminary results obtained are presented in the subsequent section.

TEL-oriented UCD methodology extends beyond the traditional iterative UCD approach [35] by focusing on essential tasks required to address learning needs. It emphasizes the importance of designing the learning path and the technological medium in parallel, ensuring that their development remains interdependent, and considers the characteristics of the intended participants.



**Fig. 1.** TEL-oriented UCD methodology, structured in six main steps (from [38]).

In detail, mapping the TEL-oriented UCD methodology (Figure 1) within ARTECOM:

1. The learners mentioned in *step 1* of the TEL-oriented UCD methodology are teenagers. In fact, during this step, learners were identified as teenagers, even those without a music creation background, because the review of relevant literature, partially presented in Section 1 ("Introduction and State of the Art"), highlighted that adolescence is a particularly sensitive period for

benefiting from electroacoustic music creation. Moreover, one of the basic needs of teenagers is precisely the opportunity to engage in musical activities without necessarily having received formal education. Similarly, we analysed the main AI-based applications for electroacoustic music creation, both commercially and academically, currently available to non-expert users in order to assess whether they meet teenagers' needs. To this end, we identified key issues that risk hindering the learning process and limiting the accessibility of these applications. The results of this analysis are presented in Section 1 ("Introduction and State of the Art"). This initial phase will inform all subsequent steps of the TEL-oriented UCD, ultimately aiming to develop a solution that considers teenagers' unique characteristics and needs.

2. The psycho-pedagogical assessment strategy in *step 2* will involve the personality assessment of teenagers participating in the study using the NEO-FFI-3 [29] as a self-report measure of personality traits. This test is specifically aimed at teenagers between the ages of 14 and 22 and is based on the well-established Big Five theory [13], which identifies five fundamental personality traits or dimensions in every individual: *openness, conscientiousness, extraversion, agreeableness, and neuroticism*. According to the Big Five theory [13], which underpins the NEO-FFI-3 [29], these traits should be understood as existing along a continuum. The test results should not be interpreted in a categorical or exclusive way, as the model assumes that the five core traits are present in every individual following a normal distribution (Gaussian curve). Consequently, most individuals tend to score near the average on each trait, while only a small percentage show extreme values. The test, therefore, provides a picture of the relative prominence of each personality trait, offering a comprehensive profile of an individual's emotional, interpersonal, experiential, attitudinal, and motivational styles. Individual results are typically described in terms of five levels: very low, low, medium, high, and very high. Based on the distribution of the normative comparison group, approximately 38% of individuals score in the medium range ( $41 \leq T \leq 59$ ), 24% in the high range ( $60 \leq T \leq 64$ ), 24% in the low range ( $36 \leq T \leq 40$ ), 7% in the very high range ( $T \geq 65$ ), and 7% in the very low range ( $T \leq 35$ ). This scoring approach enables more nuanced distinctions than simple dichotomies, offering a more accurate description of the complexity of human personality.

Moreover, *step 2* also focuses on identifying and *specifying the context of the use* of AI-digital-based installations for learning electroacoustic music creation. To this end, after administering the NEO-FFI-3 [29], the teenagers participating in the study were asked two specific questions: one about the city in which they live and another about what they would expect in order to enjoy inclusive and free educational art activities (as detailed in the next Section 3).

The outputs from this phase of the study allowed for the ideal profiling of participants, described using the *Personas & Scenario framework* [12]. As

detailed in the next section, expert music composers created electroacoustic music tracks based on this profiling, aiming to address each of the five personality traits identified through the NEO-FFI-3 [29] and the context of use analysis. This profiling was translated into specific creative choices and sound material manipulation as the basis of the future learning path for electroacoustic music creation.

3. The definition of the psycho-pedagogical plan in *step 3* will consist of a learning path delivered through tutorial-based and video-educational learning pills to explore key concepts of electroacoustic music creation. The learning path will be articulated in increasing levels of difficulty. The initial stages will introduce the basic concepts of music, such as notes, time, and rhythm, progressing to explanations and practice of more complex topics, such as the role of layering sounds in creating more dynamic and complex tracks, demonstrating how different layers combine to add depth to the music. The learning path, leveraging AI capabilities, could be adaptive, adjusting to the participant's individual skills and selecting and modifying content in a personalized manner.

Regarding the definition of system requirements in *step 3*, referring to the hardware and software specifications needed for proper functionality, these will be specified according to ISO Standards. [24].

4. The design of prototyping solutions in *step 4* will be incremental with a view to fast prototyping. This step will involve both User Interface/User Experience (UI/UX) and software prototyping, with prototypes ranging from Low-Fidelity (low-fi) to High-Fidelity (high-fi) [46], depending on the development stage. Lo-Fi will focus on wireframes, mock-ups, and concepts to define interaction flows and layouts, while Hi-Fi will integrate AI components, dynamic UI, and interactivity for real-time usability and performance validation. In fact, this step will encompass the design and implementation of the AI algorithm for electroacoustic music creation, ensuring its integration within the evolving prototype. Initially, the AI algorithm will be structured in such a way as to have  $n$  sets of musical parameters, each optimized from the  $n$  types of teenagers profiling from the sample of  $N=30$  obtained through a paired statistical analysis of the results.

Specifically, the proposed approach involves developing an adaptive AI system based on an Autoregressive with exogenous inputs (ARX) model. The goal is to learn a mapping from individual personality traits—measured using the NEO-FFI-3 [29] questionnaire—and subjective preferences (collected through an electroacoustic music modification task) to optimal audio feature configurations. In this respect, the training dataset consists of personality profiles obtained from a cohort of teenagers and user-selected song parameter adjustments made after listening to a base version of the song. The output of the learning consists of the set of parameters of the ARX model, each optimized to represent one of the five categories. Constraints on the model include the bounded nature of the audio parameters.

Overall, the AI algorithm, capable of learning and re-learning from the content on which it is trained, will propose, in subsequent iterations with each teenager, sets of parameters different from those initially associated based on profiling, thereby enhancing individual differences and variations observed between different genders.

5. Evaluation of the prototypes and psycho-pedagogical solutions in *step 5* will be performed using the most appropriate methods, starting from the number of teenagers involved in a formative/summative evaluation perspective. Specific evaluations will be conducted on both the usability of the prototype solution and the effectiveness of the proposed adaptive learning path through several statistical analyses. Usability evaluation will combine expert-based and user-based methods to ensure a comprehensive usability evaluation. Experts will conduct heuristic analysis using Nielsen's usability heuristics (e.g., error prevention, consistency) [33]. This will be complemented by user-based evaluation, which will include task-based usability testing and the Think-Aloud Protocol to directly observe participant interactions. Standardized tools (e.g., SUS [8], UEQ [42]) will be used to quantify usability performance. Likewise, qualitative insights and interviews post-task from participants will together guide prototype refinement.
6. The realization of the system solutions and psycho-pedagogical solutions in *step 6* will be fully implemented in the form of a web application following the most appropriate software engineering approaches (e.g., Agile [4]). Finally, the realization of the solution will consist of satisfying all objectives of the ARTECOM project. Once the final solution has been developed, the teenager installation interaction will be recorded to provide both an output of the experience and the opportunity to share their work with peers and others.

The study participants or their caregivers, in the case of underage teenagers, signed informed consent and were adequately informed about the aims of the study. For the entire study, compliance with regulations on information society services for participants and their caregivers will be ensured, as these AI-based digital installations are intended for minors (14-22 years). This includes adherence to Art. 8 of the General Data Protection Regulation (GDPR) [2] during development. To enhance usability, key UI/UX design guidelines tailored for adolescents (e.g., [34]) will be incorporated, such as using clear, simple language aligned with teen slang.

The Statistical Package for the Social Sciences (SPSS) software (version 22; SPSS Inc., Chicago, IL, USA) was used for all analyses.

### 3 Preliminary Outputs

The following is a description of the outputs from the completion of *steps 1* and *2* of the TEL-oriented UCD methodology and an update on the current status of the ARTECOM project.

In this regard, after the completion of *step 1* of the TEL-oriented UCD methodology - which involved, as output, the identification of the final learners in

teenagers, based on a literature review concerning the role of music for this target audience, teenager needs, and the current opportunities available for learning electroacoustic music creation through AI-based applications (described in Section 1) - we then moved on to the realization of *step 2*.

Regarding the outputs of *step 2*, firstly, a sample of N= 30 teenagers without a music creation background and with the absence of relevant clinical conditions (age:  $16.67 \pm 2.06$ ) has been selected from L'Aquila city (Abruzzo region, Italy), equally divided between men and women.

All participants completed the NEO-FFI-3 test [29] to classify the teenagers participating in the study into five predominant personality traits, i.e., openness, conscientiousness, extraversion, agreeableness, and neuroticism. The results were relatively homogeneous, with one personality trait showing a greater predominance in the sample under study compared to the others — namely, openness (25%), followed by extraversion (23%), neuroticism (19%), conscientiousness (17%), and agreeableness (16%). Each participant received a score for all five personality traits. With the aim of profiling the participants, we classified the sample based on the most predominant trait for each of them.

Subsequently, participants answered two questions related to the city where they live daily, i.e., L'Aquila:

1. Do you think that your city offers inclusive spaces and environments to share ideas, engage in cultural development, and enjoy art for free?
2. What would you expect from your city in order to actively enjoy free and inclusive educational art activities?

The answers most frequently given by the participants can be summarised with related percentages as follows.

- For Question 1: “*The city’s reality is fragmented (63%); it offers few cultural and recreational venues (47%), and there is a lack of gathering places where young people can socialize with their peers (52%).*”
- For Question 2: “*Art is quite attractive to this target group (49%). From painting to music, most respondents said that if they want to engage with art, they have to do so privately (56%). The possibility of learning in a free and interactive way through technology is appealing to all participants (100%).*”

Given that these are preliminary results, we acknowledge their limitations for their generalization and aim to expand the sample size in the near future. To this end, we are continuing to collect data and are engaging with other teenagers in the different cities of the Abruzzo region to facilitate comparisons.

The detailed analysis of all responses provided by the participants was matched with the results obtained from the NEO-FFI-3 test [29] for each participant, and the results were described using the *Personas & Scenarios framework* [12]. This framework will guide the design process and help define learning objectives. A Persona is a data-driven archetypal user model that synthesizes key behavioural patterns, goals, and needs, providing a deeper understanding of the target audience. A Scenario is a structured narrative illustrating a typical interaction between a Persona and her/his context of use, detailing conditions, motivations, tasks, and expected outcomes [12]. The profiling of the participants using the *Personas & Scenarios framework* is presented in Figures 2 to 6.

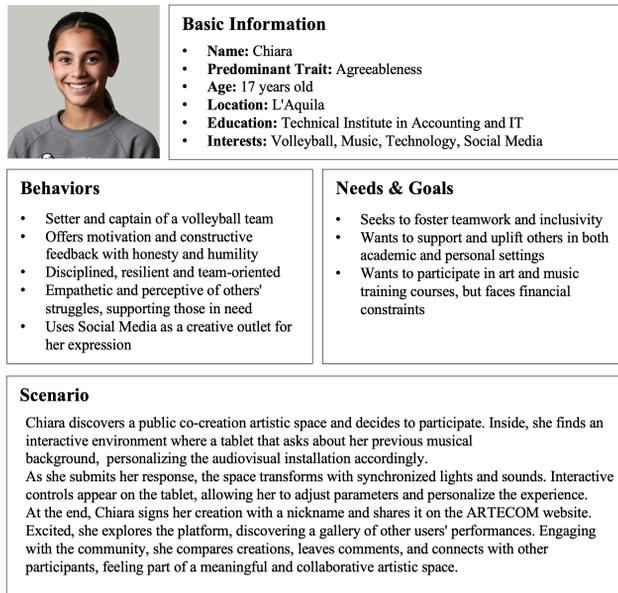


Fig. 1. *Agreeableness* - Scenario & Personas output.

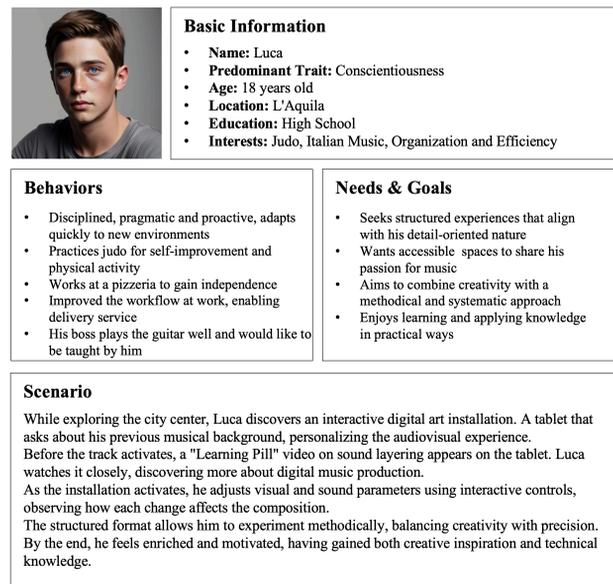


Fig. 2. *Conscientiousness* - Persona & Scenario output.

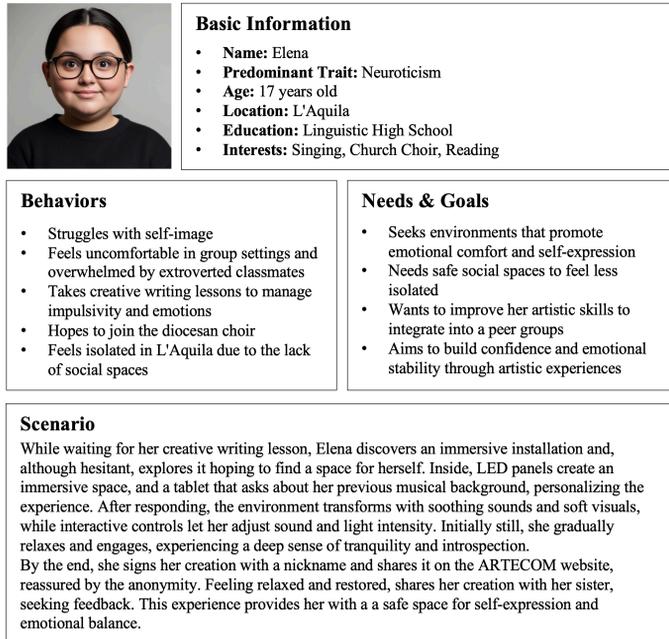


Fig. 3. *Neuroticism* - Persona & Scenario output.

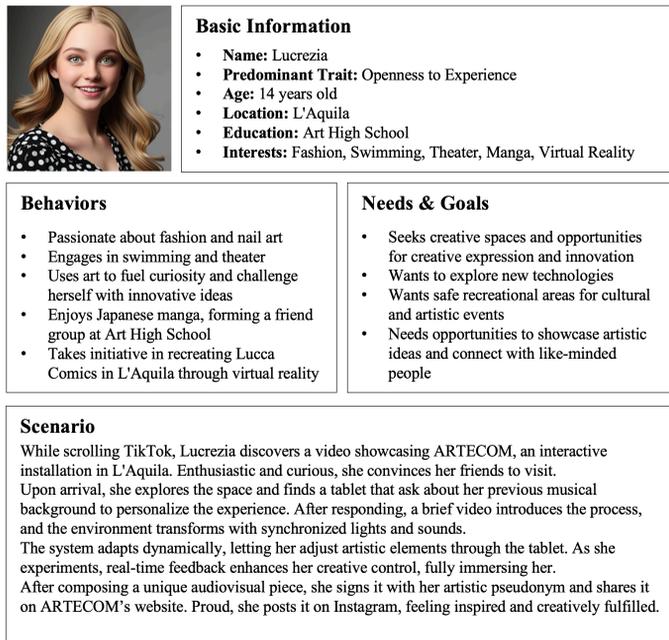
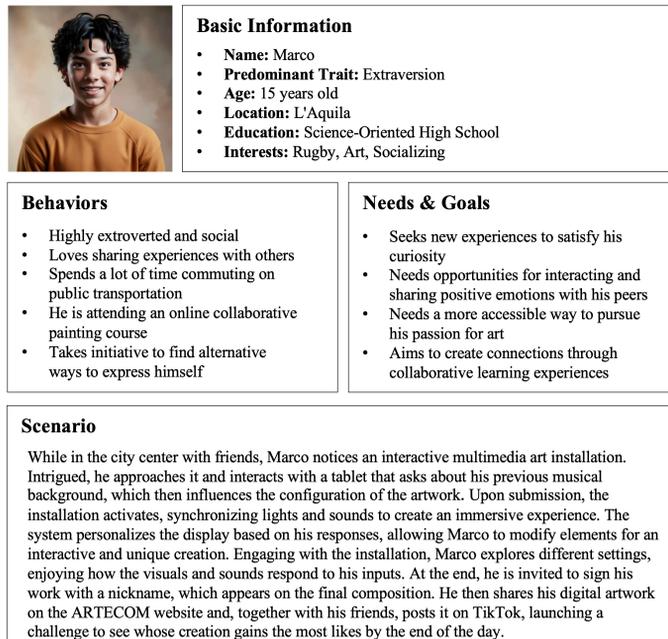


Fig. 4. *Openness to Experience* - Persona & Scenario output.



**Fig. 5** *Extraversion* - Personas & Scenario output.

The profiling just described through the *Persona & Scenario framework* has enabled us to develop ideal prototypes of end users characterized by distinctive personality traits and aspects of daily life. Profiling is a key step in the design process, as it allows us to envision a final product, i.e., AI-based digital installations, not only tailored specifically to teenagers, even those without a music creation background, but also capable of meeting their needs in terms of entertainment, learning, and expectations.

In relation to the current advancement of the project, currently, based on the *Persona & Scenario output*, i.e., the personality traits and the context of the AI-based digital installation, experienced electroacoustic music composers from the “A. Casella” Conservatory in L'Aquila created electroacoustic tracks that will serve as the foundation for the subsequent learning path (which is being implemented to also satisfy *steps 3 and 4* of TEL-oriented UCD methodology).

The development phases of electroacoustic tracks are as follows:

1. Selection of sound materials from recordings made in the city of L'Aquila itself. These recordings were subsequently processed to create a sound experience aligned with the previously identified personality traits and context of use. The goal was to bring expressive content to life. For this reason, the decision was made to work with the natural sounds of the city—elements that encapsulate and narrate the complexity of the urban environment. These materials become acoustic metaphors for various aspects of city life, evoking emotions, moods, and concepts related to everyday experiences, movement, and social dynamics.
2. Multiple recordings were carried out throughout the city following specific criteria, with the objective of capturing a wide range of sound events—from

walking through the historic centre of L'Aquila to the voices of children in social gathering spaces. The recording process was guided primarily by the following criteria:

- *Type of environment*: Indoor spaces tend to exhibit characteristic resonances but offer a more limited sonic variety, often constrained by the functional nature of the location (e.g., home, museum, café). In contrast, outdoor environments provide a broader spectrum of sounds, provided that the setting is sufficiently dynamic.
- *Mobility*: Stationary recording restricts the diversity of captured events, whereas moving through space enables the exploration of different contexts and the encounter of more heterogeneous soundscapes.
- *Urban vs. non-urban context*: Recordings conducted in non-urban environments are typically characterized by silence and repetitive natural sounds. Urban settings, by contrast, present a higher density of sonic events, influenced both by human presence (voices, activities) and the surrounding infrastructure (traffic, construction sites).
- *Time of day*: The time at which recordings are made significantly impacts the type of sounds captured. In the early morning or at sunset, natural sounds are more prominent in non-urban areas, while in urban settings, recordings mainly reflect the rhythms and activities of daily life.

Overall, these elements made it possible to capture a representative sonic portrait of the city, highlighting the diversity and distinct characteristics of the contexts explored.

3. The analysis and manipulation of the sounds were carried out according to five fundamental dimensions of density:
  - *Spectral Density*, i.e., number and distribution of frequencies: control of spectral density allowed for the emphasis or reduction of the layering within the musical material, guiding the listener through varying levels of immersion.
  - *Temporal Density*, i.e., distribution of events over time: modulating temporal density made it possible to shape the narrative flow of the sound material, alternating between moments of tension and relaxation.
  - *Textural Density*, i.e., layering and cohesion of sound materials: using synthesis and reverberation techniques, different levels of depth were created, enhancing the evocative quality of the recorded materials.
  - *Dynamic Density*, i.e., intensity variation: manipulation of intensity defines the dynamics of the sound and its perceived impact.
  - *Spatial Density*, i.e., distribution and movement of sound in space: through spatialization techniques, effects of movement and depth were achieved, reinforcing the realism and multidimensionality of the sound material.

Each of these dimensions contributed to defining the quality and complexity of the final sound material, shaping the perception of depth, tension, and movement within each individual electroacoustic track.

The electroacoustic tracks are the result of a sculptural approach to sound: starting from real-world material, then deconstructing and shaping it in both time and frequency. Sound is no longer a “means” of representation, but a raw material to be molded. They exploit two main processes: fragmentation and time-varying filtering. Following the creative and technical workflow:

1. *Sound Material Collection*: the process begins with the recording of concrete sounds: everyday objects, musical instruments, natural or urban environments, etc. The choice of sound sources may already imply a timbral, dynamic, or narrative intention.
2. *Fragmentation of Sound Objects*: the goal of this phase is to make the original sound source unrecognizable, transforming it into an abstract acoustic object. Main techniques used:
  - Cut-up and micro-editing— slicing the audio into very short segments (milliseconds or a few seconds), often at arbitrary points.
  - Time-stretching and compression— altering the duration to disrupt the natural progression of the sound.
  - Reverse playback— inverting the temporal direction of the sound.
  - Granular synthesis— breaking the sound into microscopic grains and creatively rearranging them.
  - Pitch-shifting— changing pitch without affecting duration, producing deformed sonic fragments.

The result is a collection of micro-events that retain interesting textures and dynamics but lose their original contextual identity.
3. *Time-Varying Frequency Filtering*: this phase goal is the manipulation of the timbre over time, making specific spectral components emerge or recede, exploiting:
  - Dynamic filtering (automated EQ, band-pass, notch, comb, or peak filters) — applying changes over time to specific frequency bands.
  - Spectromorphological processing— using tools such as GRM Tools, Max/MSP, Reaktor, or Kyma to sculpt the spectral evolution precisely.
  - Automation or modulation (LFOs, envelopes) — controlling filter parameters in real time to create fluid or rhythmic transformations.
  - Spectral convolution / FFT filtering— manipulating the spectral content with frequency response functions, often derived from other sources.

Time-varying filtering enables exploration of the inner structure of the sound, highlighting partials, internal noise, and hidden nuances. It's a way of giving the timbre a "voice" in motion.
4. *Structural Composition*: once the material is transformed and filtered:
  - it is assembled into a coherent form, often non-linear, based on timbral contrasts, density, dynamics, and spatial movement;
  - sequencing and spatialization tools are used (DAWs like Reaper, Ardour, Pro Tools, or specialized tools like Spat, Ircam Tools, etc.);
  - the balance between recognizability and abstraction is central: the track becomes an immersive sonic space, perceptually rich and evocative.
5. *Mixing and Mastering*: the final stage involves refining the overall dynamics, balancing levels, managing spatial depth, and ensuring the timbral transformations are perceptible and engaging.

The output was the development of an initial prototype created in the Cycling '74 Max/MSP environment. The user interface of the prototype is shown in Fig. 7, while the five electroacoustic music tracks included in the prototype are available at the following link: <https://cloud.atesaq.it/s/42bCag5fN92cwGw>. This prototype will be refined and expanded in the subsequent steps of the TEL-oriented UCD methodology.



**Fig. 7** User interface of the prototype, shown in Italian, to match the language of the current end users.

## 4 Conclusion

In this paper, we presented the first outputs of ARTECOM, an ongoing project dedicated to teenagers, with a broad mission to harness the adaptive capabilities of AI to promote learning and artistic enjoyment, particularly for those facing economic and social challenges.

Specifically, we addressed the early steps of the TEL-oriented UCD methodology (*steps 1 and 2*, as described in the methodology section), which focus on profiling end users and their context of use [16, 38]. We reported the related outcomes, highlighting the importance of designing modern AI-based technologies from the earliest stages with a thorough understanding of the target audience. In this case, the end users are teenagers, even those without a music creation background, who inherently possess distinct physical, hormonal, cognitive, and neurobiological characteristics [6, 9, 11]. For this reason, a comprehensive literature review was essential to identify their unique needs and the cognitive domains most responsive to the beneficial effects of electroacoustic music—particularly in terms of personality expression and modulation [5,20].

Simultaneously, we analysed the context in which AI-based digital installations for electroacoustic music creation are used to ensure that the final product is both engaging and meaningful for teenagers, taking into account the environments they inhabit [16, 38]. The adopted methodology—TEL-oriented UCD—furthermore supports the adaptation of user profiling and contextual analysis to other urban settings and different teenager groups, offering a methodological standard with a good degree of generalizability [16, 38]. To implement this methodology throughout the project, the design phases were carried out by a multidisciplinary team composed of developmental and educational psychologists, HCI engineers, and music composers. This multidisciplinary approach represents a key strength, ensuring that each objective and output is developed with high standards of scientific and technical quality.

At present, the learning pathway for electroacoustic music creation is under development (*step 3* of the TEL-oriented UCD methodology). Notably, the results presented in this paper are foundational to the design of that pathway thanks to TEL-oriented UCD methodology. Indeed, the results obtained through this methodology

are supported by its central feature: the personalization of the user experience—both in terms of content and learning strategy—based on user profiles and the context of the use. This methodology naturally facilitates learning through a rigorous, iterative cycle of design and evaluation, enabling continuous improvement and refinement. Combined with the adaptability of the AI-based solution, this makes the learning process highly customisable to the individual characteristics of each participant. As such, the project addresses and overcomes the limitations of current AI-based digital applications for music creation, which are dedicated only to domain expert figures, and fail to offer a structured learning path.

The personalization feature and its inclusive nature, given that the final solution will consist of free, AI-based digital installations for electroacoustic music creation, are the key aspects of the ARTECOM project, promoting a *balance* between accessibility, structured learning, and user engagement. It ensures that teenagers are active participants in the process rather than passive consumers. This feature enhances the scientific relevance of the results and underscores the broader societal impact of the study—going beyond commercial aims while still preserving the attributes of a commercially viable product. Indeed, a structured and interactive learning pathway allows teenagers, even those without a music background, to have fun, be entertained, and feel meaningfully involved while achieving educational goals.

In the near future, we will present the learning path (*Step 3* of the TEL-oriented UCD methodology) and the first prototype solution (*Step 4* of the TEL-oriented UCD methodology), with the goal of making the multidisciplinary method presented in this paper accessible to the relevant scientific community as a replicable model. The ultimate objective is to see AI not as a tool that raises ethical concerns and flattens the learning curve but rather as a means of promoting learning and the overall well-being of the individual.

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#### **CRedit author statement.**

**Sara Peretti:** Conceptualization, Methodology, Formal Analysis, Writing – original draft preparation, and Review and Editing. **Federica Caruso:** Software, Review, and Editing. **Maria Chiara Pino:** Investigation, Review, and Editing. **Fabio Franchi:** Software, Review, and Editing. **Francesco Smarra:** Software, Review, and Editing. Writing – Review and Editing. **Daniele Frigioni:** Software, Review, and Editing. Writing – Review and Editing. **Tania Di Mascio:** Conceptualization, Methodology, Software, Validation, Review, and Editing.

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