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# A decision-support system for assessing the function of machine learning and artificial intelligence in music education for network games

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**Abstract**

With the impressive enhancement and development of computer technology, artificial intelligence (AI) and machine learning (ML) are implemented in every field of life. Music is one of these sectors where AI and ML have been applied and gained traction in recent years. Both AI and ML are cutting-edge fields that are utilized to create and manipulate sounds in games, music, and other applications. Innovative and sophisticated approaches based on AI and machine learning are being used to improve music teaching. Furthermore, by employing these methods, the sounds in games can be made more efficient and effective. Evaluation of the role of AI and ML in music education is one of the most difficult and challenging areas for teaching and learning researchers due to the use of these approaches. The Fuzzy Analytical Hierarchy Process (Fuzzy AHP) approach was used to assess the role of AI and machine learning in music instruction. Fuzzy AHP is a basic and straightforward way of making better decisions based on criteria and options. In the proposed study, we used Fuzzy AHP to determine the weightages of seven criteria and five alternatives. When we tested these paradigms, we got good results that let us move forward and improve the principles and framework for AI and ML to help music education grow creatively.

**Keywords** Music education · Computer game · Intelligent approach · Machine learning · AI · Fuzzy AHP

## 1 Introduction

Artificial intelligence and machine learning are emerging fields that have attracted an increasing number of newcomers in recent years. AL and ML are the two fastest-developing technologies in human science and technology history with major breakthroughs in the fields of music education, games, and robotics. The music sector is boosted as a result of the application of these technologies, and composers have more options to produce efficient and effective music, which may then be embedded in computer games to make them more appealing. Composers have an interactive and efficient environment and tools to write attractive and effective music as well as improved music instruction for games, with recognitions of AI and machine learning technologies. Nowadays, sound is an important component of effective games, as gamer believe that sound will make games more persuasive and effective.

Research has thoroughly analyses some major techniques to use AI in music education (Holland 2000). The discipline is highly interdisciplinary, involving substantial participations from different disciplines such as music, education, AI, human computer interaction and many other disciplines. Furthermore, AI in music education itself is a very emerging field which make the usage of music effective and efficient for various purposes such as computer games and others. Shang (2019) has presented a study that reviewed the development history along with evolution

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of AI technology in music education. The study has discussed the usage and implementation of AI in music education. Furthermore, the study equated and reviewed the benefits and drawbacks of traditional as well as AI-applied music education mode. In addition, it has examined the outcomes of the study statistically via questionnaire, and assumed that the integration of music education and AI will be the novel trend of the upcoming music education. Straeubig (2020) has observed remarkable enhancements in the gaming industry using artificial intelligence technology. While these developments are explained in terms of technological progress, the way people address their cultural and societal impact is largely decoupled. The study proposes a substitute rhetoric by guessing about the development of AI in the societal system. The study further discussed the usage and implementation of artificial intelligence and machine learning in the video game industry and studied a good understanding of AI in games along with committed AI programmers. Digital games have gained importance as a new model in education and are easily accessible as well as affordable for anyone, which makes them usable and effective. Digital games offer opportunities for at-scale teaching and learning.

Giannakos et al. (2020) have presented a study to review novel research into games for assisting AI and ML in education. After studying concisely, the related research and games are selected and included in this qualitative content investigation. Based on the evaluation, the study proposes a summary of related articles and games, as well as how many games offer a specific opportunity to demonstrate the amount of several concepts in AI and ML. In the music field and games, AI and ML technologies play a primary role. And AI and ML provided more tools to enhance music education and develop attractive and memorable games. Moreover, music is used in games to make them more attractive and memorable which in turn improves the players' interest in playing games. The contributions of the proposed study are following:

- To discuss the AI and ML paradigms and their role in music education and games.
- To evaluate the efficient and effective role of AI and ML in music education.
- To evaluate the role of these AI and ML paradigms in music education for games using Fuzzy AHP method to measure the overall weightage.

The paper is structured in the sections as; Sect. 2 discusses the literature associated to the proposed research. Section 3 shows the detail of the methodology and flow of the proposed research. Results and discussions are given in Sect. 4. The paper is concluded in Sect. 5.

## 2 Literature review

AL and ML are the two most rapidly evolving primary technologies in human science and technology history, with notable successes in fields, such as music instruction, games, and robots. Researchers are attempting to develop different techniques for evaluating the contribution of AI and machine learning in game and music teaching. As a result, a variety of techniques have been devised. Zhou et al. (2017) have focused on a study that proposes a collaborative and good platform for game AI education called Botzone, aiming to make easy the teaching procedure of game AI courses and encourage the AI students to self-study. Botzone is a general online game AI platform that is designed to assess different employments of game AI by implementing them as mediators in a diversity of games and playing with each other. The presented platform has been efficiently utilized in several artificial intelligence competitions and courses. Furthermore, the structure and features of Botzone are studied and explained. Recently, artificial intelligence technology has evolved rapidly and brought a lot of enhancements in both research and industry. Amato et al. (2019) have presented a study that discusses upcoming technological advances in the field of artificial intelligence as well as their emerging impact on inventive industries. The study objective is to offer a realistic perception of the scope of AI actions in inventive organizations, present a vision of how this technology can participate for research and invention purposes in such a context, and find exploration and progress challenges.

Carbonell et al. (1983) have proposed a study that negotiates the objective of machine learning along with computer modelling of learning processes in their several manifestations, finding the theme matter of machine learning. The machine learning discipline is organized around three main research focus which are task-oriented studies, cognitive simulation, and theoretical analysis. Additionally, an equally elementary scientific aim of machine learning is the research of alternative learning appliances, including the finding of different induction algorithms, which also discusses the scope and drawbacks of certain approaches, along with the information that must be accessible to the students. Avdeeff (2019) has developed an overview that studies the first AI-human interacted album, which uses Sony's Flow Machine technologies. The study reviews the existing and developing applications of artificial intelligence in popular music creation, as well as links those applications with myths and uncertainties that have been distributed in discourses about the usage of AI in general, and how these uncertainties link to the idea of an audio uncanny valley. By presenting the concept of AIPM, the study provides a lens through which to analyze the newer and infrequent melodies and harmonization made possible through AI music generation and interrogates how this content equates to the broader speculations about authenticity in popular music as well as wider expectations of anthropocentric inventiveness. Sidana (2019) has addressed a study to evaluate the usage and implementation of artificial intelligence and its effectiveness in the field of education. The study searched for and collected 26 usable articles from Google Scholars, which were negotiated from the aspects of conceptual outline, uses, and assessment of artificial intelligence. Several conceptual outlines were identified in the study. The existing study discusses the numerous kinds of AI uses in teaching, music education, reading, and drawing, and so on, and tests them successfully. Furthermore, the study also successfully assessed the several uses of AI. However, sometimes slower speed and software glitches arise, and sometimes no benefits of utilizing the equipment over conventional tutoring are observed. Hamdaoui et al. (2015) have conducted research on how educational games ensure a functional educational experience as well as enjoyable gameplay for each type of student or gamer. By using different AI algorithms, the most profitable video games adapt the playing involvement to the gamer. The study presents an adaptive mechanism that consists of two bricks called “AI brick” and “IMSLD brick.” The AI brick will adapt the game play based on the gamer’s gaming fashion, own decisions and performance in the game. While the IMSLD brick will be based on IMSLD components to adapt the education content based on the player’s or student’s understanding and learning fashion. Thus, at the same time, the study makes sure of the fun as well as the operative educational experience.

Mich (2020) has proposed a study that AI is assisting in the computerization of tasks as well as activities that alter the job landscape as much as they have impacted on our daily routine. The first chapter of the study discusses the AI definition and its major research areas, along with its uses. The next part also negotiates the nature and importance of machine learning for AI solicitations. Current techniques are also categorized and illustrated. Furthermore, the study explained the AI equipment along with solutions for assisted functionalities and automation tasks. At the end, the upcoming trends as well as risks relevant to the uses of AI are deliberated. Nart (2016) has been shown in a study that the role of tutor has altered as the traditional teaching approaches, uses, and strategies have left its position to the learner-centered methods, strategies, and uses of the twenty-first century. The major goal of the study is to identify the software utilized that seemed to be beneficial in music education as well as the application of software in music education. To determine these goals, the study analyzed the publications and research of existing literature using a screening approach and the gathered data was brought together and interpreted. In the end, it was concluded that there is a lot of software available to be used in music education, which offers an efficient and effective education method for both tutors and learners. Yu and Ding (2020) have developed that AI tutoring is a primary part of internet education and an inevitable trend of the period. AI-created robots detect infants’ voice emotions and automatically identify and play functional music. Some music robots with certain neural networks can recognize music, examine music, and make music. In the professional music learning discipline, all types of novel collaborative teaching music intelligent systems grounded in music AI technology will be a novel mode of observing music, cognitive music, inventing music along with music learning. Recent developments of artificial intelligence technology brought a lot of enhancement in music education. Yang (2020) has concentrated on a study that presents a music tutoring technique based on AI to overcome the limitations of traditional music instructing techniques. In order to enhance the quality of music tutoring, the novel method combines the characteristics of traditional music education with those of artificial intelligence. The investigational outcomes indicate that AI can efficiently enhance the quality of traditional music instruction as well as excellently promote the growth of music learning.

Zhaoran (2021) has focused a study that explains the difference between listening to music activities has been focused. The survey was arranged to find out the impact of music education. The outcomes indicate that listening to music is an essential hobby, specifically when most kids are open to music. Furthermore, the study indicates that home music schools and music schools have a moderately good attitude towards meeting several machine learning as well as processor home music tutoring activities such as listening and chilling at home, making emotional as well as social connections, along with inspiration and active education relevant to a specific topic and music school. Sturm et al. (2019) have proposed a study that implements machine learning to music modelling and typically presents model designs, coaching techniques along with datasets, as well as measures the performance of the system utilizing quantitative measures like qualitative listening tests. The study intends to investigate its usefulness and impact on practical experts, and then build on those findings to inform the growth and applications of machine learning. Furthermore, the study develops and utilize numerous uses of machine learning for music invention as well as shows an open performance of the outcomes. Ceylan et al. (2021) have presented a study that shows music genre classification is one of the most efficient and reliable methods in music classification. The study’s goal is to develop a deep learning algorithm that can categorize ten different music genres. The study makes the classification through the

GTZAN dataset to expose the effectiveness of the model by relating it with others. Furthermore, the analysis utilizes a CNN to categorize music genres, taking into account the earlier successful outcomes. Finally, the study develops a model that performs better in categorizing music genres by utilizing fewer data points than previous revisions. Jamshidi et al. (2021) have focused on a study whose objective is to lay the foundation for education and performing music virtually. MOOCs are developing as we are moving toward virtual classes. Through MOOCs, existing music courses mostly concentrate on peer assessment as a means of evaluating the learners' performance. The key aim of the study is to condense the teacher's load as well as offer a virtual concurrent performance response. As a contribution to music learning, the study presents a novel technological outline to computerize music education for learning how to play any preferred song through current machine learning strategies for flexibility in numerous learning fashions. Pan. (2021) has developed a study that demonstrates how the collaboration of AI technology and advanced information technology has enabled a novel way for the enhancement of the modern music industry. With the development of virtual learning, virtual classes, and other tutoring approaches, the modern music learning mode has begun to undergo significant changes. The integrated use of artificially functional technology in the discipline of music learning can better reform music education. In addition, the study also negotiates the collaboration of artificial intelligence with music education in real-world cases. Xu et al. (2021) have concentrated on a study that found music information is broadly utilized in music information retrieval, music suggestion, music therapy, and so on. The study made connections between audio features, individual factors, and emotions by implementing machine learning approaches. In order to predict the supposed emotion and felt emotion of music correspondingly, they utilized audio features along with individual features as input. The outcomes indicate that the actual individual features can expressively enhance the model's effect as well as that constant individual features have no effect.

Tian (2020) The features of generality as well as uniqueness of music key learners in autonomous education in the network atmosphere are examined through the analysis and study on the autonomous education of music main learners in the network atmosphere, and some issues are discovered in the study presented solutions to these issues to assist learners of music majors to utilize scientific and improved virtual education methods to learn music theory education along with abilities built up to compensate for the deficiency of traditional instructing approaches and attain the purpose of sponsoring as well as enhance the effectiveness of learning. Yuan (2020) has proposed a study in which the status quo of the universal deficiency of AI elementary knowledge in postgraduates at conservatories of music and art is examined. The requirement of providing standard science subjects in "Music and AI" is highlighted. The interdisciplinary article outcomes in the AI and music education disciplines are explained, categorized, and shortened. Also, the study presented and explained the contents of the standard science subject "Music and AI" in detail. Zhang and Yang (2021) have presented a study that reviews the related knowledge of machine learning as well as some important complications in the development of the Ologit model and also shows some particular ideas for designing a distance tutoring system for music and dance developments based on the existing college syllabus system setting. Furthermore, the study examines the particular condition of the distance music dance learning system to enhance the learning value of music dance courses and has faith that a learning variant model can be built to increase the learners' attentiveness in the courses of music dance. In addition, the study efficiently enhanced the quality of music and dance education. Micheloni et al. (2019) have focused on a case-study that discusses a videogame called Musa, in which gamers are led into an imaginary world where music is magic, as well as every movement is carried out through it, integrated with an educational path, to make gamers capable of learning and, in continuous moments, to summarized this knowledge from a game, just by playing. The videogame was evaluated, and the results show that learners are capable of learning some fundamental knowledge to play the piano during the game after the first couple of sessions. Additionally, the outcomes found from the experiment point out the tangible opportunity to use this application with numerous tools such as guitar, flute, or voice. Dai. (2021) has focused on a study to analyzed the intelligent tutoring design with the assistance of AI technology. The study employs cutting-edge information technologies such as big data, IoT, and mobile internet, as well as AI, to create a comprehensive set of scientifically intelligent music tutoring design models. Perception instructing offers a recommendation for the overall process, before, during, as well as after class, assisting tutors to better carry out wisdom instructing, assisting learners to expand interactive and autonomous education, as well as promoting the wisdom conversion of tutoring approaches along with learning approaches to an assured extent. Furthermore, music classroom tutoring has become more directed and efficient. Chen and Wen. (2021) have developed a study that recommends the Music Composition along with Melody Generation Adjustable (MCMGA) architecture to develop adaptive music. Its key aim is to develop music in real-time that reflects numerous moods that can be achieved via a solo combination of the chord-sequence originator on a cross graph. Also, the study examined a search melody predictor along with an emotional expression concept. Two quantitative consumer studies were found by testing the program. The first is based on music generation, while the second is based on valence expression through total dissonance. The study results indicate that every other portion of the creation and propagation grows the perceptual worth of the produced music along with the relative efficiency of the analysis of reactivity through dissonance grounded on different parameters such as accessibility, usability, and so on.

## 3 Methodology

Artificial intelligence and machine learning are two cutting-edge technologies that are used to create and modify sounds in games, music, and other applications. To improve music education, innovative and advanced technologies based on AI and machine learning are being deployed. Additionally, using these strategies, game noises can be made more efficient and effective. Due to the usage of these methodologies, evaluating the function of AI and ML in music education is one of the most demanding and difficult topics for teaching and learning researchers. Plut and Pasquier (2020) have mentioned that music is an important part of videogames and plays a key role in the enhancement of the gaming industry. Most of the writers of the music used in games are human composers, and the music is played as a linear piece behind gameplay. Adaptive or creative music systems can be used to lengthen the musical content or make novel musical content utilizing AI and algorithms. In addition, the study proposes a classification of generative music in games to enable analysis and negotiation of generative music systems. Also, the study shows an analysis of the existing state of the art of generative music systems in games, as well as negotiates the challenges and perceptions of generative music for games. Baratè et al. (2013) have concentrated on a study that proved that possessive games have proved to be an efficient tool in several disciplines. The key aim of the study is to demonstrate some potential uses for music and their benefits. The study also offered a number of definitions along with examples focusing on the use of serious games in music learning. After indicating a universal method to this problem, the next part of the study concentrated on a multilayer technique for music information to get a rich and comprehensive music description for a music piece. Further, the study indicates some case studies and uses. Rogers (2017) has proposed that there are several forms of sound in games, and they have the potential to efficiently impact the gamer experience. The study examines that how the existence of several kinds of audio impacts gamer immersion, interaction, and efficiency and also analyze the usage and implementation of audio in the increasingly immersive virtual reality gaming technology. Furthermore, the study explores how audio design impacts the gamer experience in traditional and VR games, and also helps to consider the usage of sound within gamer-game collaboration, by observing the immersive effect of particular audio kinds along with their differences.

Mostly decisions include uncertainty and ambiguity that are normally faced in every sector of life. To handle these issues and evaluate the role of AI and ML, we used Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method. Fuzzy AHP method is the extended form of AHP method used to deal with uncertainty, ambiguity, and fuzzy judgement but mostly used in multi-criterions decision-making complications. In the presented study, Fuzzy AHP method is used to assessed the role of AI and ML paradigms in music education for games. Figure 1 shows the goal, criterions and alternatives. Here the goal is to evaluate the role of AI and ML, criterions are qualitative, responsive, formalized, beneficial, specificity, rationality, and performance along with different alternatives which are presented as paradigm 1, paradigm 2, paradigm 3, paradigm 4, and paradigm 5.

### 3.1 Features extraction and selection

We read the literature and mined several features from it for the aim of gathering features, as indicated in Table 1.

Following the collection of features from previous work, we chose seven common features for evaluating AI and machine learning technologies in music learning as shown in Table 2. These features are widely used in many suggested studies.

### 3.2 Fuzzy AHP for weight calculation using geometric mean method

The current research created a decision matrix for these features and give values to them which are given below:

*Step 1.* Draw a pairwise Decision matrix n*n.

$$A = \begin{bmatrix} a11 & \dots & a1n \\ a21 & \dots & a2n \\ an1 & \dots & ann \end{bmatrix} \tag{1}$$

*Step 2.* Replace linguistic numbers by fuzzy numbers. For reciprocal the formula is:

$$A^{-1} = (l, m, u)^{-1} = (1/u,\ 1/m,\ 1/l) \tag{2}$$

whereas l is lower number, m is middle number, and u is upper number.

*Step 3.* We calculate the Fuzzy geometric value by the given formula.

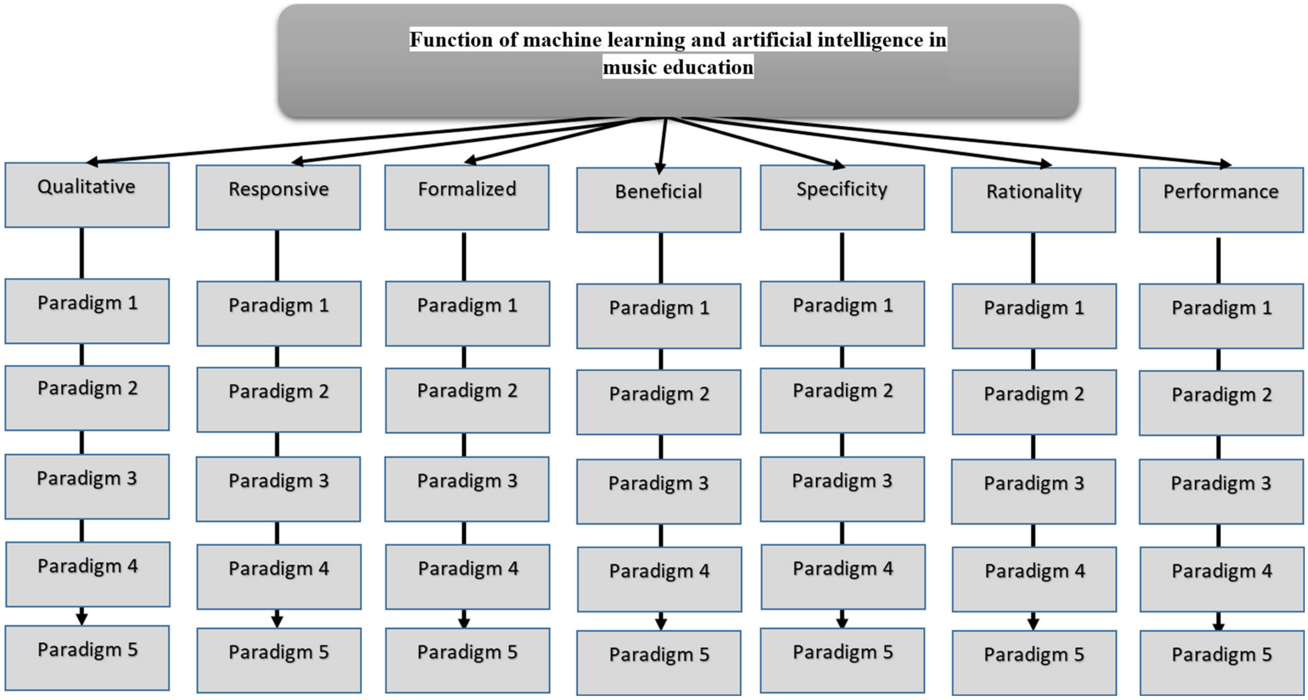


**Fig. 1** Goal, criterions and alternatives of the proposed approach

$$\begin{aligned}\text{Fuzzy geometric value } (r_i) &= A_1 * A_2 \ldots * A_n \\ &= ((l_1, m_1, u_1) * (l_2, m_2, u_2) * (l_3, m_3, u_3) * \ldots\ldots * (l_n, m_n, u_n)) \\ &= \Big((l_1 * l_2 * l_3 * \ldots * l_n)^{1/n}, \\ &\quad (m_1 * m_2 * \ldots\ldots * m_n)^{1/n}, (u_1 * u_2 * \ldots\ldots * u_n)^{1/n}\Big)\end{aligned} \tag{3}$$

where "n" indicate the number of criteria.

*Step 4.* For measuring the fuzzy weights ($W_i$), we know the formula which is;

$$W_i = r_i * (r_1, r_2, r_3, \ldots\ldots, r_{10})^{-1} \tag{4}$$

*Step 5.* Defuzzification: Weights are measured through the following formula:

$$\text{Centre of Area } (w_i) = l + m + u/3 \tag{5}$$

by implementing the above average formula, we get the weight values from fuzzy weights.

*Step 6.* If the total sum of weights is greater than 1 so transform weight values to normalized form. The formula for normalized weights are,

$$\text{Normalized Weights } = \frac{wi}{\sum^i wi} \tag{6}$$

The fuzzy scale is given in Table 3.

By applying step 1, we draw a pair-wise decision matrix of 7*7 which is consists of criterions and their values as shown in Table 4.

Through the implementation of step 2, here the linguistic numbers are replaced by fuzzy numbers which is used for further calculation like findings weightage etc. as shown in Table 5.

By using Eq. 3, the fuzzy geometric mean value of each criteria is calculated and used for further calculation like findings fuzzy weights etc. as shown in Table 6.

Here multiple steps from 4 to 6 are applied to calculate multiple values such as fuzzy weight values, weights and normalized weights values. Also ranked each criteria according to their value. In addition, the given table is representing the weightage value of each criteria and their ranking as shown in Table 7.

Figure 2 indicating the ranking of criterions while representing that each criteria has different color.

Repeat step 1 to 6 for all levels of the hierarchy, look the tables from 7 to 13.

To calculate the weightage of alternatives, we draw alternatives based decision matrix based on qualitative criteria. The given matrix is 5*5 and containing the values of each alternative along with Fuzzy Geometric values, fuzzy weights, weights and normalized weights and steps 1 to 6 is repeated for the overall calculation as shown in Table 8.

In the given Table 9, we draw a pair-wise comparison matrix having alternatives based on responsive criteria. Also it contains fuzzy numbers and different values like

**Table 1** Extracted features from literature review

| Citations | Extracted features |
|---|---|
| Holland (2000) | Substantial, Cognitive psychology, autonomous, interaction, abbreviate, reasonable, formalized, Well-defined, Expressive, Sophisticated, Quality, Clear |
| Straeubig (2020) | Constructive, Consciousness, Affordable credit, parametrized, Computational Creativity, Novelty, Usefulness, Creative, Responsive |
| Zhou et al. (2017) | Expandability, Simplified, Competitive, Interactive, Repetitive, Real-time, Complexity, Validating, Optimization, Expansible, Supportive, Rationality |
| Amato et al. (2019) | Creative, Accurate, Realistic, Media Diversity, Personalization, Inclusivity, Cost, Efficiently, Interactive endeavor, Innovative, Complexity, Expressivity, Qualitative, Formalized |
| Avdeeff (2019) | Authenticity, Specificity, Creativity, Captivating, Interaction, Generative Modelling, Extensive, Quality, Responsive, Concretize, Rationality |
| Sidana (2019) | Effectiveness, Conceptual, Augmented, Efficiency, Possibility, Applicability, multi-agent systems, inadequacy, modify, Qualitative, Comprehensible, Interactive, Supportive, Responsive |
| Nart (2016) | Accessible, Manageable, Beneficial, Effective, Efficient, Descriptive, Interactive, Useful, Concretize, Comprehensive, Formalized |
| Yu and Ding (2020) | Sensitivity, Interactive, Cognitive, Manageable, Complexity, Stability, Rationality, Accuracy |
| Zhaoran. (2021) | Qualitative, Performance, standardized, Effective, Scaffolding, Exactness, Efficiently, Accuracy, Interactive |
| Sturm et al. (2019) | Qualitative, Usefulness, Beneficial, Effectively, Performance, Creative, Acceptable, Sensible, Specificity |
| Ceylan et al. (2021) | Valid, Effective, Efficiency, Complex, Maintaining, Accuracy, Meaningful, Performance, Storage |
| Jamshidi et al. (2021) | Performance, Real-time, Sizes, Automate, Adaptability, Qualitative |
| Tian (2020) | Autonomous, Knowledge, Efficiency, Reasonable, Effectively, Accessible, Specificity, Availability, Accurate, |
| Yuan (2020) | Rationality, Sensibility, Interactive, Effective, Efficiency, Optimize, Performance |
| Zhang and Yang (2021) | Diversify, Attentive, Viability, Specificity, Quality, Reasonable, Efficiency, Synthesized |
| Dai (2021) | Personalized, Adaptive, Efficiency, Interactive, Effective, Accurately, Dynamic, Qualitative, Performance, Stability, Formalized, Beneficial |
| Chen and Wen (2021) | Quality, Real-time, Adaptive, Feasible, Effectiveness, Reactivity, Usability, Accessibility, Performance, Adjustable, Responsive, Rationality |
| Plut and Pasquier (2020) | Generative, Sequential, Descriptive, Interaction, Rationality, Adaptive, Real-time, Resource-intensive, Performance |
| Folorunso et al. (2021) | Accuracy, Time-domain, Performance, Descriptive, Consistent, Compatible, Optimize |
| Baratè et al. (2013) | Effective, Notable, Cognitive, Intellectual, Interactivity, Usable, Responsive, Specificity, Rationality, Computer-driven |

**Table 2** Select common features

| No | Features |
|---|---|
| 1 | Qualitative |
| 2 | Responsive |
| 3 | Formalized |
| 4 | Beneficial |
| 5 | Specificity |
| 6 | Rationality |
| 7 | Performance |

**Table 3** Fuzzy scale

| Equal | Moderate | Strong | Very strong | Extremely strong |
|---|---|---|---|---|
| 1 | 3 | 5 | 7 | 9 |
| (1,1,1) | (2,3,4) | (4,5,6) | (6,7,8) | (9,9,9) |
| Intermediate values | | | | |
| 2 | 4 | 6 | 8 | |
| (1,2,3) | (3,4,5) | (5,6,7) | (7,8,9) | |

fuzzy geometric values, fuzzy weights and weightage of each alternative.

To calculate weightage of alternatives, we draw a pair-wise decision matrix of alternatives based on formalized criteria and identify the normalized weightage values of each alternatives as shown in Table 10.

**Table 4** Pair-wise comparison matrix

| Index | Criteria | Qualitative | Responsive | Formalized | Beneficial | Specificity | Rationality | Performance |
|---|---|---|---|---|---|---|---|---|
| 1 | Qualitative | 1 | 5 | 1/3 | 4 | 7 | 1/2 | 3 |
| 2 | Responsive | 1/5 | 1 | 2 | 3 | 1/4 | 1/3 | 6 |
| 3 | Formalized | 3 | 1/2 | 1 | 1/5 | 6 | 4 | 1/3 |
| 4 | Beneficial | 1/4 | 1/3 | 5 | 1 | 4 | 3 | 1/5 |
| 5 | Specificity | 1/7 | 4 | 1/6 | ¼ | 1 | 1/2 | 5 |
| 6 | Rationality | 2 | 3 | 1/4 | 1/3 | 2 | 1 | 7 |
| 7 | Performance | 1/3 | 1/6 | 3 | 5 | 1/5 | 1/7 | 1 |

**Table 5** Fuzzified pair-wise decision matrix

| Index | Criteria | Qualitative | Responsive | Formalized | Beneficial | Specificity | Rationality | Performance |
|---|---|---|---|---|---|---|---|---|
| 1 | Qualitative | 1,1,1 | 4,5,6 | 1/4,1/3,1/2 | 3,4,5 | 6,7,8 | 1/3,1/2,1/1 | 2,3,4 |
| 2 | Responsive | 1/6,1/5,1/4 | 1,1,1 | 1,2,3 | 2,3,4 | 1/5,1/4,1/3 | 1/4,1/3,1/2 | 5,6,7 |
| 3 | Formalized | 2,3,4 | 1/3,1/2,1/1 | 1,1,1 | 1/6,1/5,1/4 | 5,6,7 | 3,4,5 | 1/4,1/3,1/2 |
| 4 | Beneficial | 1/5,1/4,1/3 | ¼,1/3,1/2 | 4,5,6 | 1,1,1 | 3,4,5 | 2,3,4 | 1/6,1/5,1/4 |
| 5 | Specificity | 1/8,1/7,1/6 | 3,4,5 | 1/7,1/6,1/5 | 1/5,1/4,1/3 | 1,1,1 | 1/3,1/2,1/1 | 4,5,6 |
| 6 | Rationality | 1,2,3 | 2,3,4 | 1/5,1/4,1/3 | 1/4,1/3,1/2 | 1,2,3 | 1,1,1 | 6,7,8 |
| 7 | Performance | 1/4,1/3,1/2 | 1/7,1/6,1/5 | 2,3,4 | 4,5,6 | 1/6,1/5,1/4 | 1/8,1/7,1/6 | 1,1,1 |

**Table 6** Fuzzy geometric value ($r$)

| Criteria | Qualitative | Responsive | Formalized | Beneficial | Specificity | Rationality | Performance | Fuzzy Geometric value |
|---|---|---|---|---|---|---|---|---|
| Qualitative | 1,1,1 | 4,5,6 | ¼,1/3,1/2 | 3,4,5 | 6,7,8 | 1/3,1/2,1/1 | 2,3,4 | 1.41,1.81,2.37 |
| Responsive | 1/6,1/5,1/4 | 1,1,1 | 1,2,3 | 2,3,4 | 1/5,1/4,1/3 | ¼,1/3,1/2 | 5,6,7 | 0.70,0.92,1.19 |
| Formalized | 2,3,4 | 1/3,1/2,1/1 | 1,1,1 | 1/6,1/5,1/4 | 5,6,7 | 3,4,5 | ¼,1/3,1/2 | 0.87,1.12,1.49 |
| Beneficial | 1/5,1/4,1/3 | ¼,1/3,1/2 | 4,5,6 | 1,1,1 | 3,4,5 | 2,3,4 | 1/6,1/5,1/4 | 0.79,0.99,1.25 |
| Specificity | 1/8,1/7,1/6 | 3,4,5 | 1/7,1/6,1/5 | 1/5,1/4,1/3 | 1,1,1 | 1/3,1/2,1/1 | 4,5,6 | 0.54,0.66,0.85 |
| Rationality | 1,2,3 | 2,3,4 | 1/5,1/4,1/3 | ¼,1/3,1/2 | 1,2,3 | 1,1,1 | 6,7,8 | 0.93,1.31,1.71 |
| Performance | ¼,1/3,1/2 | 1/7,1/6,1/5 | 2,3,4 | 4,5,6 | 1/6,1/5,1/4 | 1/8,1/7,1/6 | 1,1,1 | 0.48,0.58,0.72 |

**Table 7** Criterions weightages and Ranking using Fuzzy Geometric value

| Index | Criteria | Fuzzy geometric value ($r_i$) | Fuzzy weights ($W_i$) | Weights ($w_i$) | Normalized weights | Ranking |
|---|---|---|---|---|---|---|
| 1 | Qualitative | 1.41,1.81,2.37 | 0.146,0.244,0.412 | 0.267 | 0.246 | 1 |
| 2 | Responsive | 0.70,0.92,1.19 | 0.072,0.124,0.207 | 0.134 | 0.123 | 5 |
| 3 | Formalized | 0.87,1.12,1.49 | 0.090,0.151,0.259 | 0.166 | 0.153 | 3 |
| 4 | Beneficial | 0.79,0.99,1.25 | 0.082,0.133,0.217 | 0.144 | 0.133 | 4 |
| 5 | Specificity | 0.54,0.66,0.85 | 0.056,0.089,0.147 | 0.097 | 0.089 | 6 |
| 6 | Rationality | 0.93,1.31,1.71 | 0.096,0.176,0.297 | 0.189 | 0.174 | 2 |
| 7 | Performance | 0.48,0.58,0.72 | 0.049,0.078,0.125 | 0.084 | 0.077 | 7 |

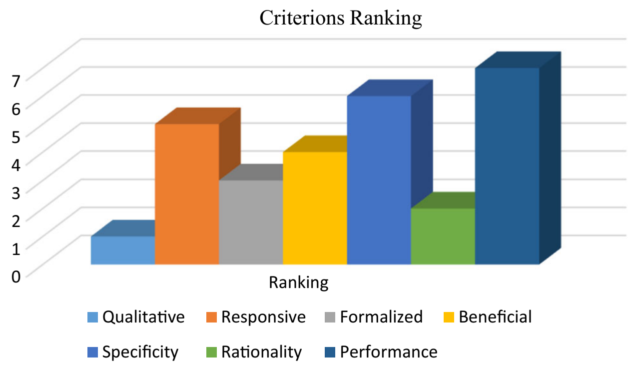


**Fig. 2** Rankings of criterions

For the calculation of weightage of each alternative, we draw n*n matrix of alternatives based on beneficial criteria by repeating steps 1 to 6 as shown in Table 11.

By repeating and applying steps 1 to 6, we draw the matrix and calculate the normalized weight of each alternative based on specificity criteria as shown in Table 12.

Table 13 indicating the normalized weight values of each alternative based on rationality criteria and the values is calculated by using the above Eqs. 1, 2, 3, 4, 5 and 6

Here, we draw alternatives pair-wise comparison matrix based on performance criteria and calculate the normalized weightage of each alternative using the given equations as shown in Table 14.

In the given Table 15, we calculate results and ranking each alternative by using the following formula.

$$\begin{bmatrix} W1 \\ W2 \\ . \\ . \\ . \end{bmatrix} * \begin{bmatrix} w11 & w12 & w1m \\ w21 & w22 & w2m \\ . & . & . \\ . & . & . \\ wm1 & wm2 & wmm \end{bmatrix} \tag{7}$$

where "m" shows the number of alternatives.

By employing the given matrix formula, we calculate the results of all given alternatives and ranking them as shown in Table 15.

Figure 3 representing the results and rankings of each alternative. While results values have blue color and rankings have orange color.

## 4 Result and discussions

Due to the rapid development of computer technology, artificial intelligence and machine learning approaches are used and implemented in every sector of life. Music

**Table 8** Alternatives pair-wise comparison matrix based on qualitative criteria

| Qualitative | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy Weights | Weights ($W_i$) | Normalized weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 2,3,4 | 4,5,6 | 1,2,3 | 1/5,1/4,1/3 | 1.09,1.49,1.88 | 0.167,0.284,0.451 | 0.301 | 0.284 |
| Paradigm 2 | 1/4,1/3,1/2 | (1,1,1) | 5,6,7 | 1/5,1/4,1/3 | 4,5,6 | 1.00,1.19,1.47 | 0.154,0.227,0.352 | 0.244 | 0.230 |
| Paradigm 3 | 1/6,1/5,1/4 | 1/7,1/6,1/5 | (1,1,1) | 6,7,8 | 2,3,4 | 0.76,0.92,1.09 | 0.117,0.175,0.261 | 0.184 | 0.173 |
| Paradigm 4 | 1/3,1/2,1/1 | 3,4,5 | 1/8,1/7,1/6 | (1,1,1) | 1/6,1/5,1/4 | 0.45,0.56,0.72 | 0.069,0.106,0.172 | 0.115 | 0.108 |
| Paradigm 5 | 3,4,5 | 1/6,1/5,1/4 | ¼,1/3,1/2 | 4,5,6 | (1,1,1) | 0.86,1.05,1.30 | 0.132,0.200,0.312 | 0.214 | 0.202 |

**Table 9** Alternatives pair-wise comparison matrix based on responsive criteria

| Responsive | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized Weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 3,4,5 | 5,6,7 | 1,2,3 | 1/8,1/7,1/6 | 1.13,1.46,1.75 | 0.175,0.278,0.414 | 0.289 | 0.273 |
| Paradigm 2 | 1/5,1/4,1/3 | (1,1,1) | 2,3,4 | ¼,1/3,1/2 | 4,5,6 | 0.83,1.04,1.31 | 0.128,0.198,0.310 | 0.212 | 0.201 |
| Paradigm 3 | 1/7,1/6,1/5 | 1/4,1/3,1/2 | (1,1,1) | 6,7,8 | 2,3,4 | 0.84,1.02,1.26 | 0.130,0.194,0.298 | 0.207 | 0.196 |
| Paradigm 4 | 1/3,1/2,1/1 | 2,3,4 | 1/8,1/7,1/6 | (1,1,1) | 1/6,1/5,1/4 | 0.42,0.53,0.69 | 0.065,0.101,0.163 | 0.109 | 0.103 |
| Paradigm 5 | 6,7,8 | 1/6,1/5,1/4 | ¼,1/3,1/2 | 4,5,6 | (1,1,1) | 0.99,1.18,1.43 | 0.153,0.225,0.338 | 0.238 | 0.225 |

**Table 10** Alternatives pair-wise comparison matrix based on formalized criteria

| Formalized | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized Weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 7,8,9 | 5,6,7 | ¼,1/3,1/2 | 1/3,1/2,1/1 | 1.23,1.51,1.99 | 0.180,0.280,0.467 | 0.309 | 0.289 |
| Paradigm 2 | 1/9,1/8,1/7 | (1,1,1) | 2,3,4 | 1,2,3 | 4,5,6 | 0.97,1.30,1.58 | 0.142,0.241,0.371 | 0.251 | 0.235 |
| Paradigm 3 | 1/7,1/6,1/5 | ¼,1/3,1/2 | (1,1,1) | 6,7,8 | 2,3,4 | 0.84,1.02,1.26 | 0.123,0.189,0.296 | 0.202 | 0.189 |
| Paradigm 4 | 2,3,4 | 1/3,1/2,1/1 | 1/8,1/7,1/6 | (1,1,1) | 6,7,8 | 0.86,1.08,1.38 | 0.126,0.201,0.324 | 0.217 | 0.203 |
| Paradigm 5 | 1,2,3 | 1/6,1/5,1/4 | ¼,1/3,1/2 | 1/8,1/7,1/6 | (1,1,1) | 0.34,0.45,0.56 | .049,0.083,0.131 | 0.087 | 0.081 |

**Table 11** Alternatives pair-wise comparison matrix based on beneficial criteria

| Beneficial | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized Weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 7,8,9 | 3,4,5 | 1/4,1/3,1/2 | 5,6,7 | 1.92,2.29,2.75 | 0.263,0.382,0.566 | 0.403 | 0.384 |
| Paradigm 2 | 1/9,1/8,1/7 | (1,1,1) | 1/6,1/5,1/4 | 3,4,5 | 4,5,6 | 0.73,0.87,1.01 | 0.100,0.145,0.208 | 0.151 | 0.143 |
| Paradigm 3 | 1/5,1/4,1/3 | 4,5,6 | (1,1,1) | 1/8,1/7,1/6 | 2,3,4 | 0.72,0.87,1.04 | 0.098,0.145,0.214 | 0.152 | 0.144 |
| Paradigm 4 | 2,3,4 | 1/5,1/4,1/3 | 6,7,8 | (1,1,1) | 1,2,3 | 1.19,1.60,1.99 | 0.163,0.267,0.409 | 0.279 | 0.265 |
| Paradigm 5 | 1/7,1/6,1/5 | 1/6,1/5,1/4 | ¼,1/3,1/2 | 1/3,1/2,1/1 | (1,1,1) | 0.28,0.35,0.47 | 0.038,0.058,0.096 | 0.064 | 0.061 |

**Table 12** Alternatives pair-wise comparison matrix based on specificity criteria

| Specificity | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized Weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 4,5,6 | 1/8,1/7,1/6 | 2,3,4 | 7,8,9 | 1.47,1.75,2.03 | 0.217,0.313,0.442 | 0.324 | 0.310 |
| Paradigm 2 | 1/6,1/5,1/4 | (1,1,1) | 5,6,7 | 3,4,5 | 1/6,1/5,1/4 | 0.82,0.99,1.16 | 0.121,0.177,0.252 | 0.183 | 0.175 |
| Paradigm 3 | 6,7,8 | 1/7,1/6,1/5 | (1,1,1) | 1,2,3 | 5,6,7 | 1.33,1.68,2.01 | 0.196,0.301,0.438 | 0.311 | 0.298 |
| Paradigm 4 | 1/4,1/3,1/2 | 1/5,1/4,1/3 | 1/3,1/2,1/1 | (1,1,1) | 3,4,5 | 0.54,0.69,0.96 | 0.079,0.123,0.209 | 0.137 | 0.131 |
| Paradigm 5 | 1/9,1/8,1/7 | 4,5,6 | 1/7,1/6,1/5 | 1/5,1/4,1/3 | (1,1,1) | 0.41,0.47,0.56 | 0.060,0.084,0.122 | 0.088 | 0.084 |

**Table 13** Alternatives pair-wise comparison matrix based on rationality criteria

| Rationality | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | ¼,1/3,1/2 | 1/6,1/5,1/4 | 3,4,5 | 6,7,8 | 0.93,1.13,1.37 | 0.138,0.211,0.321 | 0.223 | 0.210 |
| Paradigm 2 | 2,3,4 | (1,1,1) | 5,6,7 | 1/3,1/2,1/1 | 1/6,1/5,1/4 | 0.88,1.12,1.47 | 0.131,0.209,0.345 | 0.228 | 0.214 |
| Paradigm 3 | 4,5,6 | 1/7,1/6,1/5 | (1,1,1) | 5,6,7 | 1,2,3 | 1.22,1.57,1.90 | 0.181,0.293,0.446 | 0.306 | 0.288 |
| Paradigm 4 | 1/5,1/4,1/3 | 1,2,3 | 1/7,1/6,1/5 | (1,1,1) | 1/5,1/4,1/3 | 0.35,0.45,0.57 | 0.052,0.084,0.133 | 0.089 | 0.083 |
| Paradigm 5 | 1/8,1/7,1/6 | 4,5,6 | 1/3,1/2,1/1 | 3,4,5 | (1,1,1) | 0.86,1.06,1.36 | 0.128,0.198,0.319 | 0.215 | 0.202 |

**Table 14** Alternatives pair-wise comparison matrix based on performance criteria

| Performance | Paradigm 1 | Paradigm 2 | Paradigm 3 | Paradigm 4 | Paradigm 5 | Fuzzy geometric value ($r_i$) | Fuzzy weights | Weights ($W_i$) | Normalized weights ($W_i$) |
|---|---|---|---|---|---|---|---|---|---|
| Paradigm 1 | (1,1,1) | 2,3,4 | 1/5,1/4,1/3 | 4,5,6 | 1/8.1/7,1/6 | 0.72,0.87,1.04 | 0.088,0.134,0.208 | 0.143 | 0.133 |
| Paradigm 2 | ¼,1/3,1/2 | (1,1,1) | 2,3,4 | 6,7,8 | 1/3,1/2,1/1 | 0.99,1.28,1.74 | 0.121,0.198,0.348 | 0.222 | 0.206 |
| Paradigm 3 | 3,4,5 | ¼,1/3,1/2 | (1,1,1) | 1,2,3 | 1/5,1/4,1/3 | 0.68,0.92,1.19 | 0.083,0.142,0.238 | 0.154 | 0.143 |
| Paradigm 4 | 1/6,1/5,1/4 | 1/8,1/7,1/6 | 1/3,1/2,1/1 | (1,1,1) | 1/6,1/5,1/4 | 0.25,0.30,0.39 | 0.030,0.046,0.078 | 0.051 | 0.047 |
| Paradigm 5 | 6,7,8 | 1,2,3 | 3,4,5 | 4,5,6 | (1,1,1) | 2.35,3.08,3.72 | 0.289,0.477,0.744 | 0.503 | 0.468 |

**Table 15** Results and ranking of alternatives using fuzzy AHP method

| Criteria alternatives | Qualitative | Responsive | Formalized | Beneficial | Specificity | Rationality | Performance | Results | Rankings |
|---|---|---|---|---|---|---|---|---|---|
| Criteria Weights | 0.246 | 0.123 | 0.153 | 0.133 | 0.089 | 0.174 | 0.077 | | |
| Paradigm 1 | 0.284 | 0.273 | 0.289 | 0.384 | 0.310 | 0.210 | 0.133 | 0.27 | 1 |
| Paradigm 2 | 0.230 | 0.201 | 0.235 | 0.143 | 0.175 | 0.214 | 0.206 | 0.203 | 2 |
| Paradigm 3 | 0.173 | 0.196 | 0.189 | 0.144 | 0.298 | 0.288 | 0.143 | 0.201 | 3 |
| Paradigm 4 | 0.108 | 0.103 | 0.203 | 0.265 | 0.131 | 0.083 | 0.047 | 0.134 | 5 |
| Paradigm 5 | 0.202 | 0.225 | 0.081 | 0.061 | 0.084 | 0.202 | 0.468 | 0.175 | 4 |

education is one of the primary sectors among them in which AI and ML are used and make music fields develop. Both AI and ML provide different intelligent tools to compose effective and attractive music for games and make the music and games enjoyable for users. By discussing these technologies, we evaluate the role of AI and ML in music education by using the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method. First, we identified the goal, criteria, and alternatives and then calculated the weightage values of each criteria and alternative. Furthermore, we compare the alternatives based on each criterion to calculate their weightage values and rank them. In the study, it was determined that the qualitative criteria have high importance with a value of 0.246 by following rationality criteria with a value of 0.174, formalized criterion with a value of 0.153, beneficial criterion

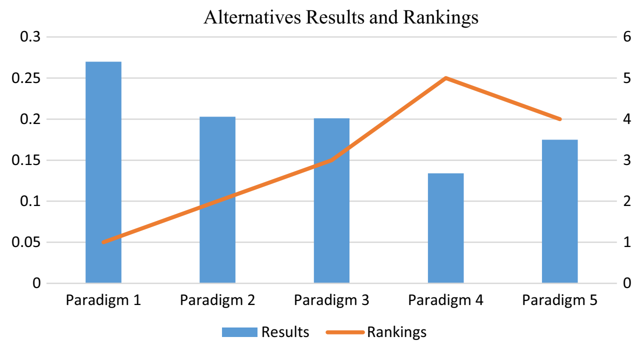


**Fig. 3** Results and rankings of alternatives

with a value of 0.133, responsive criterion with a value of 0.123, specificity criteria having a value of 0.089, and the worst one is the performance criterion with a value of 0.077. After calculating the weightage of each criterion, we measure the weightage of alternatives based on criteria, which indicates that paradigm 1 has higher importance with a result value of 0.27 and rank 1 by following paradigm 2 with a result value of 0.203 and rank 2, paradigm 3 having a result value of 0.201 and rank 3, and paradigm 5 with a value of 0.175 and rank 4, and paradigm 4 with a value of 0.134 and rank 5. The study efficiently evaluates the role of AI and ML paradigms in music education and also discusses their different methods used in music education. Figure 4 indicates the normalized weightage values along with the rankings of each criteria.

Figure 5 showing the overall weightage values, results and ranking of each alternative.

## 5 Conclusion

Artificial intelligence and machine learning approaches are entrenched in music education as a result of the rapid growth of information technology. Composing high-quality music with AI and ML technology is critical for a composer. The music in games has a direct impact on gamers' productivity and experience, and developers have used AI

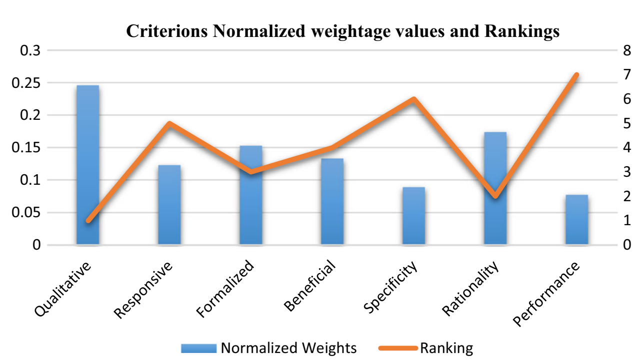


**Fig. 4** Normalized weightage values and rankings of criterions

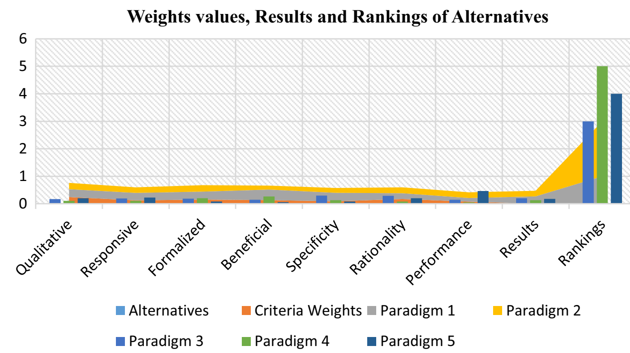


**Fig. 5** Overall weightage values, results and rankings of alternatives

and machine learning to include sounds in games to reflect many circumstances in games, such as fear, suspense, and providing player information. Visually impaired people can benefit from a game's appealing audio by being guided to make different moves depending on the situation. Furthermore, a variety of AI and machine learning-based equipment is available to help students learn music more effectively and efficiently, as well as to improve games by including higher-quality sounds. The suggested research examines how artificial intelligence and machine learning paradigms in music education are evaluated. We used the Fuzzy AHP method to evaluate various options, which is a relatively basic and strong decision-making method. Following other alternatives, the alternative paradigm 1 has achieved a high rank and placed at position first with a value of 0.27, while the criterion qualitative has a high ranking and placed with a weightage value of 0.246. The results show that the Fuzzy AHP method is particularly successful and efficient in evaluating the use of AI and machine learning in music education.

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## Declarations

**Conflict of interest** The authors have no conflict of interest.

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