Troubadour: Inverse Dictation Games for Ear Training

Klara Žniderščič[1], Matija Podbreznik[1], Žiga Klun[1], Peter Šavli[2][a], Matija Marolt[1][b] and Matevž Pesek[1][c]

[1]*Faculty of Computer and Information Science, University of Ljubljana, Slovenia*

[2]*Conservatory of Music and Ballet Ljubljana, Slovenia*

Keywords: Music Theory, E-Learning, Gamification, Sight-Singing, Ear-Training.

Abstract: This study evaluates the integration of inverse melodic and rhythmic dictation exercises into the gamified e-learning Troubadour platform. The platform offers gamified and personalised applications for different types of ear and music theory training. The platform was developed as a complementary tool to support music theory classes with automated ear-training exercises with automatic generation and evaluation. To further extend its usability, we present two ear-training apps, which invert the standard ear-training techniques of listening and writing down the solution. The inverse melodic and rhythmic dictation exercises now offer voice or instrument user input as a user response to the written melodic or rhythmic prompt. In this paper, we gathered user feedback using UEQ and Meega+ questionnaires, which showed positive results, particularly in terms of novelty, perspicuity, and efficiency. Notably, gamification elements such as achievement badges and leaderboards have been integrated in line with other exercises on the platform and contributed to a dynamic and engaging learning experience. These results highlight the potential of inversion games in music education and emphasise the importance of gamified platforms in enhancing the overall learning experience.

1 INTRODUCTION

In the constantly evolving field of education, technological progress is playing an increasingly important role and is leading to innovative educational tools. The integration of e-learning approaches into curricula already demonstrated positive effects in various areas of education. In addition, researchers suggested that incorporating gamified elements into e-learning processes can benefit students by making tasks more engaging and motivating (Saleem et al., 2022).

Within the domain of music education, there are several aspects that need to be considered by developers of teaching methods. While e-learning of music theory through written user input has been in use for some time, the important aspect of music is also its auditory nature. The task of training the ear for rhythm and melody can be accomplished in two ways—through auditory recognition and by performing given exercises. While neither is trivial, the latter presents developers with additional challenges in terms of recognizing the auditory input.

In response to these challenges, we propose an extension to our existing e-learning platform Troubadour, tailored for music theory exercises. This extension introduces inversion games, i.e. inverse rhythmic and melodic dictation training that seamlessly integrates with Troubadour's existing exercises and gamification elements. To evaluate the effectiveness and user experience of the proposed exercises, we conducted user studies. The positive feedback from participants in terms of engagement, usability, and overall experience speaks to the effectiveness of the proposed work. Therefore, this research contributes to the advancement of music education technology and emphasises the importance of considering the auditory dimensions of music learning through gamified e-learning platforms.

The following section reviews related work and describes the Troubadour platform. Details of the proposed extension, the challenges encountered and the experimental setup are presented in Section 3. Section 4 presents comprehensive evaluation results that shed light on the potential impact on music education. Conclusions and future work are presented in Section 5.

[a] https://orcid.org/0000-0002-8097-7983
[b] https://orcid.org/0000-0002-0619-8789
[c] https://orcid.org/0000-0001-9101-0471

Žniderščič, K., Podbreznik, M., Klun, Ž., Šavli, P., Marolt, M. and Pesek, M.
Troubadour: Inverse Dictation Games for Ear Training.
DOI: 10.5220/0012747200003693

In *Proceedings of the 16th International Conference on Computer Supported Education (CSEDU 2024) - Volume 1*, pages 606-613
ISBN: 978-989-758-697-2; ISSN: 2184-5026

2 RELATED WORK

2.1 E-Learning and Gamification

Within the ever-evolving educational landscape, the merging of technology and pedagogy has led to innovative paradigms, particularly in the areas of e-learning and gamification. As educational environments increasingly shift to virtual platforms, research into effective learning methods and the incorporation of game elements, known as gamification, has proven to be a compelling strategy to engage and motivate learners in digital spaces. The majority of research and evaluations have focused predominantly on higher levels of education (Woody, 2021; Urh et al., 2015; De Sousa Borges et al., 2014; Kyewski and Krämer, 2018), and covered different areas such as music (Biasutti et al., 2023; Woody, 2021; Wagner, 2017), medicine (Morton et al., 2016), database management (Hassan et al., 2019), or a range of subjects (Aparicio et al., 2019; Kyewski and Krämer, 2018). Most studies report on the positive aspects of using modern technologies, such as flexibility, accessibility, self-paced learning, personalization and instant feedback. In addition, some studies focused on the challenges that arise when introducing e-learning (Biasutti et al., 2023; Martinez-Garcia et al., 2023). Biasutti et al. showed that the transition to distance learning in Italian primary school during the COVID-19 pandemic encountered obstacles due to the suddenness of pedagogical changes and teachers' insufficient technological skills. Teachers also expressed concerns about the detrimental effects of distance learning on many students, especially younger students. However, positive outcomes were reported in terms of familiarisation with information and communication technologies (ICT), and it was suggested that more deliberate and supported implementation could allow for a smoother and better transition. Furthermore, Martinez-Garcia et al. present both the opportunities and challenges associated with the integration of artificial intelligence into e-learning.

Gamification is defined as the use of game elements and mechanics in non-game contexts (Deterding et al., 2011), however the line between games and gamified applications is often blurred. In their literature review on gamification, Behl et al. (2022) identified four main themes—personalization, learning styles, learner engagement and game elements. The most commonly used game elements, as described by Antonaci et al. (2019), are badges, leaderboards, points, feedback, challenges, likes/social features, communication channels, narratives, levels, progress bars, teams, agents, medals, avatar, trophies, time limit, task, virtual currency, personalization features, mission, replayability, goal indicators, competition, win status. In a survey of primary school children survey and a literature review by Nand et al. (2019), graphics, feedback and challenge were identified as the most attractive features of computer games. While Kyewski and Krämer (2018) could not prove any significant improvement through the use of gamification and grades or quiz results were not influenced by badges, such game elements do not hinder the increase in learning outcomes, fostering activity, and motivation. Furthermore, De Freitas (2018) shows that games are an effective learning tool and widespread adoption is only a matter of time. It is therefore becoming increasingly important to harmonise the different disciplinary perspectives, address methodological challenges and develop a common terminology. In research on massive open online courses (MOOCs), gamification has been found to play a central role in success, as it positively influences several aspects of the courses (usage, individual impact and organisational impact) (Aparicio et al., 2019). An advanced approach to gamification is the personalization of the learning application. Hassan et al. developed a system that provides students with different gamification elements depending on their learning type. The results showed that adaptive gamification elements and activities selected according to learners' learning dimensions significantly increased factors such as motivation, course completion, interest, and user interaction in the e-learning course (Hassan et al., 2019).

2.2 Sight Reading and Sight Singing

In the area of music education, Schüler (2021) addresses the challenges faced by instrumentalists and vocalists by highlighting their respective weaknesses in singing-related exercises and ear training tasks. To counteract student "un-motivation," Schüler advocates integrating technological tools like online karaoke and platforms such as SmartMusic, which lead to higher student motivation, better performance in less time, improved audiation skills, and improved solfege skills compared to traditional singing exercises. The concept of audiation, which is crucial to improving sight-singing skills, is at the heart of these efforts. Research shows that incorporating familiar music choices and feedback mechanisms through platforms like SmartMusic, which provide visual and audio feedback, significantly increases student motivation and performance. In addition, Schüler highlights the effectiveness of various software tools such as EarMaster Pro, MacGamut, Practica Musica, Au-

ralia, Teoria.com and EarTrainer, the latter of which allows teachers to create and assess melodic, rhythmic and harmonic dictations.

In recent years, numerous applications have been developed to improve sight-singing and sight-learning. Ella[1], a sight-singing ear-training app, stands out by offering engaging exercises that include gamified elements such as leaderboards and scores, paired with pitch evaluation and detailed analysis and feedback on the user's performance. ABRSM (Associated Board of the royal Schools of Music)[2] offers various music trainer apps with gamified elements, covering piano and violin scales, sight-reading, music theory, and aural training, the latter being used to improve sight-singing. Many exercises are automatically marked, and there are also tools for reviewing and evaluating performance. Perfect Ear[3] offers various exercises for ear training, rhythm and melody dictation, sight-reading, absolute pitch, and note singing, which are suitable for self-learning as they do not allow monitoring by a teacher. MyEarTraining[4] has proven to be helpful in increasing success in the "Western Music Theory and Ear Training" course (Sezer and Temiz, 2023). It offers singing exercises, progress tracking, cross-device synchronization, and customizable exercise generation. Sight Reading Factory[5] Pavlović (2018) supports the user with customizable sight-reading exercises for instruments and vocals. The program is particularly useful for schools as it provides sight-reading exercises for full ensemble, but it lacks the function of automatic feedback for the user. Feedback can only be given by the teacher via the assignment function. The improvement of sight-reading skills is also addressed in ToneGym[6], iClef (different clef positions on the staff) (Baratè et al., 2023), and Adventure in Music Land (for children aged 9-13). The apps are mostly available as web apps or in the iOS and Google Play stores.

2.3 Troubadour

In recent years, Pesek et al. have been developing Troubadour, a gamified e-learning platform tailored for ear training (Pesek et al., 2020a,b, 2022). This web-based open-source[7][8] application is specifically geared towards learning music theory and aims to engage students in a dynamic and personalized learning experience through a series of exercises. The exercises on the platform cover various aspects including melodic and interval dictation, rhythmic dictation, and harmony exercises. Troubadour was developed in collaboration with a music conservatory and successfully meets the needs of both teachers and students. It addresses teachers' concerns about technical skills by providing a non-complex user interface while meeting students' needs for motivation through gamification elements. The platform offers features such as user administration and tracking, automatic exercise generation, and difficulty levels aligned with the conservatory curriculum. Troubadour has been integrated into music theory courses and has received positive feedback from students for its user-friendly interface and positive impact on students' exam results. Troubadour stands out as an easily expandable tool that is accessible across all major platforms. Most notably, the application utilizes gamification elements such as user profiles, avatar creation, achievement badges, progression levels, and leaderboards to provide an engaging and rewarding learning environment.

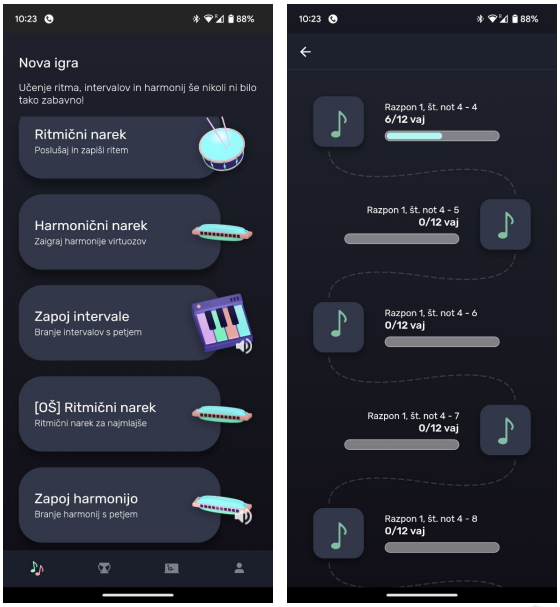
Troubadour was published as a mobile application for both Android[9] and iOS[10] platforms, along with the recently re-designed user interface (Fig. 1). The platform offers a mobile-first user experience for existing rhythmic, interval and harmony games available both as mobile app and web interface[11].

3 INVERSION GAMES

As an extension of the existing Troubadour app, we propose the integration of inversion games to help improve students' sight-singing skills. The introduction of new features, in particular inverse rhythmic and melodic dictation training, fits seamlessly into the existing exercises and gamification elements of the app. While the existing regular rhythmic and melodic dictation tasks ask users to transcribe the audio examples, the proposed inverse dictations involve performing a written rhythmic or melodic pattern. During the development process, however, challenges arose in the processing of the auditory input.

In the inverse rhythmic dictation exercises, users are given a written example of a rhythmic pattern and are required to record the rhythm by singing it into the

[1] https://ellaapp.io
[2] https://www.abrsm.org
[3] https://www.perfectear.app
[4] https://www.myeartraining.net
[5] https://www.sightreadingfactory.com
[6] https://www.tonegym.co
[7] https://bitbucket.org/ul-fri-lgm/troubadour_backend
[8] https://bitbucket.org/ul-fri-lgm/troubadour_flutter
[9] https://play.google.com/store/apps/details?id=si.trubadur.v2
[10] https://apps.apple.com/si/app/trubadur-si/id6449623053
[11] Available at: https://trubadur.si



(a) Games view. (b) In-game progress view.
Figure 1: Troubadour mobile interface.

device's microphone. Once they have confirmed their recording, they automatically receive feedback. The app processes the provided audio signal with a binary representation for each detected note and compares it with the binary reference representation calculated based on the original pattern. Tolerances are set for the synchronization and comparison of the two binary patterns, including the start time tolerance (which allows shifts in the start index of the dictated note) and the duration tolerance (which allows the duration of the dictated note to be extended or shortened by a maximum of 25% compared to the length of the corresponding note in the generated signal).

Similarly, in inverse melodic and harmonic dictation exercises, the user is provided with melodic pattern or arpeggiated chords. Based on the given reference note, the user records the pattern and submits the recording for evaluation. Flutter audio capture library was used during the recording process due to its capability for real-time audio capturing. The information about the frequencies is obtained by pitch detection libraries, based on the Yin algorithmm (De Cheveigne and Kawahara, 2002), and each note is represented as a list of values that takes into account the recognized frequencies in the human voice. The predominant frequency is converted into a musical notation and compared with the notation of the reference pattern. Initially, the recording was depicted using musical notes to represent both the user input and the reference pattern. Subsequently, we decided to enhance the visualization by incorporating a piano roll alongside the existing musical note representation with clear differentiation between correct and incorrect notes. Furthermore, users were provided with the flexibility to adjust the octave of the pattern to better align with their vocal range.

During the last six years of the Troubadour platform development, the gamified e-learning platform has continued to uphold its commitment to providing a dynamic and engaging learning experience. Notably, the gamification elements, including achievement badges, progress levels, and performance ratings on leaderboards, are also included in the newly developed exercises. The incorporation of these elements not only motivates students but also adds an element of healthy competition, enhancing the overall educational experience within the Troubadour ecosystem.

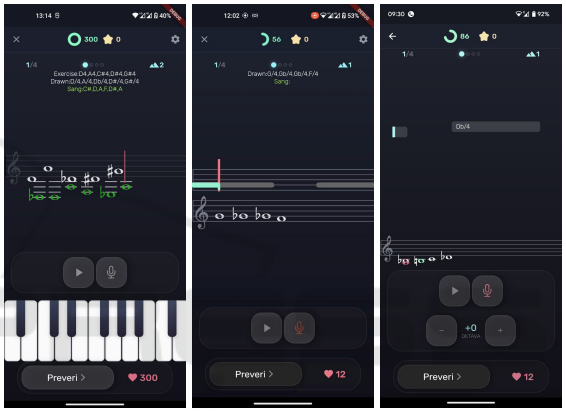


Figure 2: Three versions of the inverse interval dictation game. The final version contains the piano roll as a real-time visual aid, showing the sang pitch in a form of a blue box (left part of the screen).

3.1 Experimental Design

To collect feedback and assess the overall user experience, we conducted a two-part survey, one for each tool. First, participants were asked to complete a demographic questionnaire, in which they provided information about their gender, age, the instrument they play, years of formal instruction, and years of music school attendance.

3.1.1 User Experience Questionnaire

The user experience with the newly introduced tools was evaluated using the User Experience Questionnaire (UEQ). This questionnaire covers aspects of both pragmatic (goal-oriented) and hedonic (non-goal-oriented) quality and consists of 26 items categorized into six scales: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty (Laugwitz et al., 2008). Each scale item consists of

two terms with opposite meanings, with half of the items on a scale beginning with the positive term and the other half of the items beginning with the negative term. The provided analysis tools are tailored to accommodate this term order. Participants ranked each item on a 7-point Likert scale (Schrepp, 2015). Users were provided with the official Slovenian translation of the UEQ to ensure accurate responses.

Table 1: 26 items of the 6 scales of the UEQ as they were presented to the users(Schrepp et al., 2014).

Scales	Pairs of items	
Attractiveness (pure valence)	annoying	enjoyable
	good	bad
	unlikable	pleasing
	unpleasant	pleasant
	attractive	unattractive
	friendly	unfriendly
Perspicuity (pragmatic)	not understandable	understandable
	easy to learn	difficult to learn
	complicated	easy
	clear	confusing
Efficiency (pragmatic)	fast	slow
	inefficient	efficient
	impractical	practical
	organized	cluttered
Dependability (pragmatic)	unpredictable	predictable
	obstructive	supportive
	secure	not secure
	meets expectations	does not meet expectations
Stimulation (hedonic)	valuable	inferior
	boring	exiting
	not interesting	interesting
	motivating	demotivating
Novelty (hedonic)	creative	dull
	inventive	conventional
	usual	leading edge
	conservative	innovative

The UEQ handbook (Schrepp, 2015) provides the following interpretation of the results:

- Bad: In the range of the 25% worst results.
- Below Average: 50% of the results in the benchmark are better than the result for the evaluated product, 25% of the results are worse.
- Above Average: 25% of the results in the benchmark are better than the result for the evaluated product, 50% of the results are worse.
- Good: 10% of the results in the benchmark data set are better and 75% of the results are worse.
- Excellent: In the range of the 10% best results.

3.1.2 Meega+ Questionnaire

The inverse melodic and harmonic dictation tool was further evaluated using an adapted Meega+ (Model for the Evaluation of Educational Games) questionnaire, which was developed for the systematic assessment of the quality of educational games in computer education from a student's standpoint (Petri et al., 2018). This model comprises two primary quality factors—game experience and usability—and their respective dimensions. To streamline the evaluation and avoid redundancy with UEQ metrics, we selected seven specific metrics:

- I had fun with the game.
- This game is appropriately challenging for me.
- The game contributed to my learning in this course.
- The game design is attractive (interface, graphics, cards, boards, etc.).
- I would recommend this game to my colleagues.
- The game rules are clear and easy to understand.
- When I make a mistake, it is easy to recover from it quickly.

The answers were recorded on a 5-point Likert scale, with 1 being "strongly disagree" and 5 being "strongly agree" In addition, open-ended questions were used to get feedback on what users liked, suggestions for improvement, and additional comments.

4 RESULTS

The first experimental group focused on the new inverse rhythmic dictation tool and consisted of 15 participants. The majority of the participants were male and accounted for 73.3% of the participants, while the proportion of female participants was 26.7%. The age distribution showed that the vast majority, 66.7%, were up to 25 years old. 20% fell into the age group of 26 to 40 years and 13.3% into the age group of 41 to 60 years. No participant was over 61 years old. The group consisted predominantly of musicians (86.7%), while the proportion of music teachers was lower (13.3%). A significant proportion of participants demonstrated proficiency in playing multiple instruments: 33.3% playing two instruments and 26.7% playing three instruments. In terms of musical instrument proficiency, the majority of participants demonstrated proficiency in playing the piano, constituting 46.7%, followed by guitar and singing, both at 33.3%. Other instruments included drums, accordion, trumpet, euphonium, double bass, French horn, and tuba. The duration of formal learning varied, with 1 participant having no formal learning, 1 participant with 1 year, 6 participants with 6 to 9 years, and 7 participants with 10 or more years.

The second experimental group, focusing on the inverse melodic and harmonic dictation, was more complex. The experiment lasted for two weeks and

included 7 participants in the first week and 8 in the second week, with 5 participants taking part in both weeks. After the first week of evaluation, the tool was improved based on user feedback. All participants were first-year students at the Ljubljana Conservatory of Music and Ballet. The majority of the participants were male and made up 86.7% of the total. The average age of the participants was 17.47 years, with an average of 7.8 years of playing an instrument and 6.3 years attending music school. The most common instrument among the participants was the saxophone, which was played by four people. Mobile phone platforms were varied, with 8 participants using Android and 7 using iOS.

The results of the UEQ questionnaires show predominantly positive feedback from the participants involved in the research. The creators of the questionnaire's highlight that, given the calculation of means across different people with different opinions and response tendencies, values above +2 or below -2 are extremely unlikely to occur (Schrepp, 2015). As expected, the initial assessment of the inverse melodic dictation resulted in lower scores in the first week, which improved in the subsequent assessment.

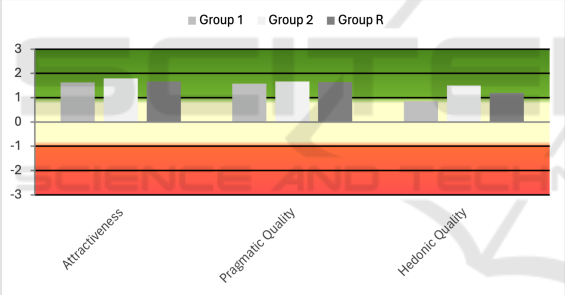


Figure 3: UEQ results of both groups in Week 2 of melodic tool analysis and rhythmic tool evaluation group.

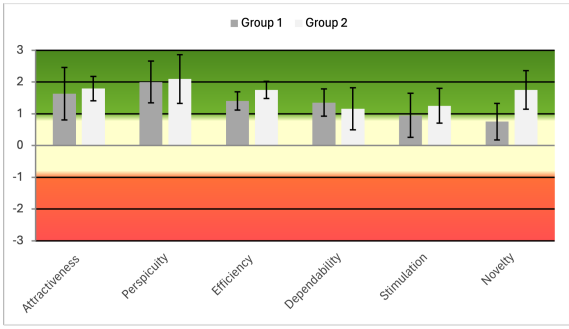


Figure 4: Comparison of UEQ results between both groups in Week 2 of melodic tool analysis.

In the first group, participants rated each scale higher in the second evaluation, with the exception of Stimulation. Conversely, the second group, being unfamiliar with the previous version, rated each scale higher than the first group, with the exception of Dependability. A visual representation of this comparison can be found in Figure 4. Compared to the evaluation of the inverse rhythm dictation tool evaluation, the only higher scores were recorded on the Efficiency scale. The lowest overall score received the Novelty scale in the first week of the evaluation. In addition, pragmatic quality scales received higher scores than hedonic quality scales, as depicted in Figure 3.

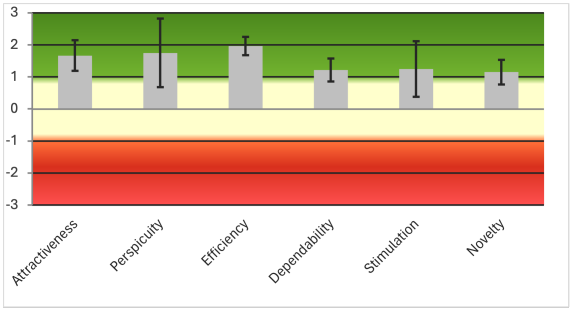


Figure 5: UEQ results of rhythmic tool analysis.

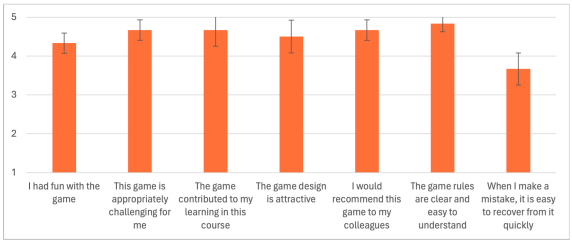


Figure 6: Results of Meega+ questionaire.

In line with the benchmarks for interpreting the UEQ results (Schrepp, 2015), the rating "Excellent" was awarded for Novelty and Perspicuity in Group 2, and Efficiency in Group R. Attractiveness was rated "Good", while Dependability and Stimulation were classified as "Above Average" in Group 2 (also in Group R).

The results of a part of the Meega+ questionnaire (see figure 6) were also positive, with all average scores above the mean of the 1-5 scale. It is worth noting that the only category that did not achieve an average score above 4 is related to error management and the ability to correct errors. These results contribute to an overall positive assessment of the user experience, as they indicate a high level of satisfaction with various aspects.

4.1 Suggestions for Improvement

Suggested improvements include increasing the sensitivity of the application, implementing more precise audio recognition to increase the accuracy of the ex-

ercises, more customization options in terms of adjusting the level of difficulty and tolerance for deviations from the ideal rhythm, the ability to disable the visual metronome, integrating an audible metronome, emphasizing the importance of correct rhythm notation, recognizing clapping, and adding polyrhythm exercises. Other suggested improvements include smoother operation, correction of errors in exercise generation, and implementation of the natural (♮) sign.

4.2 Educators' Opinion

The evaluation of the inverse rhythm dictation by two music teachers provides valuable information on its practical implementation in music lessons. The first teacher emphasizes the importance of cultivating a natural sense of rhythm and an emotional connection to music and points out that the application may not be suitable for younger students as it is geared towards self-directed learning. In contrast, the second educator sees significant potential in the application, especially if it includes more complex rhythms and features. This educator can envision the functionality benefiting musicians of all levels, provided it meets accurate notation standards.

5 CONCLUSION AND FUTURE WORK

The results of the study show overall positive feedback from participants who used the newly developed inverse rhythmic and melodic dictation tools.

Regarding the inverse melodic dictation, the initial lower scores in the first week improved in the subsequent evaluation, which was in line with expectations. The second group, who were unfamiliar with the previous version, generally rated each scale higher than the first group, indicating positive acceptance. The Meega+ questionnaire further underpinned the positive results. However, it is worth noting that the category relating to error management and the ability to correct errors received a score of slightly less than 4, suggesting that there is still room for improvement in this particular aspect. More specifically, the user experience could be further improved by taking into account the specific suggestions of students and teachers.

Overall, the positive feedback and constructive suggestions indicate that the tools can effectively support music education and self-study. The inclusion of gamification elements, as seen in the Troubadour platform, adds an engaging and motivating layer to the learning experience.

Inverse melodic dictation exercises have already been integrated into the production app and are becoming increasingly popular with students and teachers. In the upcoming update of the Troubadour platform, we plan to introduce inverse rhythm dictation exercises, which were evaluated in the present study.

ACKNOWLEDGEMENTS

This research was conducted as part of the basic research project Music for the young people since 1945 and Jeunesses Musicales in Slovenia [project number J6-3135], funded by the Slovenian Research and Innovation Agency from the state budget.

REFERENCES

Antonaci, A., Klemke, R., and Specht, M. (2019). The Effects of Gamification in Online Learning Environments: A Systematic Literature Review. *Informatics*, 6(3).

Aparicio, M., Oliveira, T., Bacao, F., and Painho, M. (2019). Gamification: A key determinant of massive open online course (MOOC) success. *Information & Management*, 56(1):39–54.

Baratè, A., Brugaletta, A., and Ludovico, L. (2023). A Mobile Serious Game to Foster Music Sight Reading with Different Clefs:. In *Proceedings of the 15th International Conference on Computer Supported Education*, pages 397–403.

Behl, A., Jayawardena, N., Pereira, V., Islam, N., Giudice, M. D., and Choudrie, J. (2022). Gamification and e-learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda. *Technological Forecasting and Social Change*, 176.

Biasutti, M., Antonini Philippe, R., and Schiavio, A. (2023). E-learning during the COVID-19 lockdown: An interview study with primary school music teachers in Italy. *International Journal of Music Education*, 41(2):256–270.

De Cheveigne, A. and Kawahara, H. (2002). YIN, a fundamental frequency estimator for speech and musica). *ournal of the Acoustical Society of America*, 111(4):1917–1930.

De Freitas, S. (2018). Are Games Effective Learning Tools? A Review of Educational Games. *Journal of Educational Technology & Society*, 21(2):74–84.

De Sousa Borges, S., Durelli, V. H. S., Reis, H. M., and Isotani, S. (2014). A systematic mapping on gamification applied to education. In *Proceedings of the 29th Annual ACM Symposium on Applied Computing*, SAC '14, pages 216–222.

Deterding, S., Dixon, D., Khaled, R., and Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining Gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, volume 11, pages 9–15.

Hassan, M., Habiba, U., Majeed, F., and Shoaib, M. (2019). Adaptive gamification in e-learning based on students' learning styles. *Interactive Learning Environments*, 29.

Kyewski, E. and Krämer, N. C. (2018). To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course. *Computers & Education*, 118:25–37.

Laugwitz, B., Held, T., and Schrepp, M. (2008). Construction and Evaluation of a User Experience Questionnaire. In Holzinger, A., editor, *HCI and Usability for Education and Work*, Lecture Notes in Computer Science, pages 63–76.

Martinez-Garcia, A., Horrach-Rosselló, P., and Mulet-Forteza, C. (2023). Evolution and current state of research into E-learning. *Heliyon*, 9(10).

Morton, C. E., Saleh, S. N., Smith, S. F., Hemani, A., Ameen, A., Bennie, T. D., and Toro-Troconis, M. (2016). Blended learning: how can we optimise undergraduate student engagement? *BMC Medical Education*, 16(195).

Nand, K., Baghaei, N., Casey, J., Barmada, B., Mehdipour, F., and Liang, H.-N. (2019). Engaging children with educational content via Gamification. *Smart Learning Environments*, 6.

Pavlović, S. T. (2018). The application Sight Reading Factory: Digitalization of sight singing and reading disciplines. *Artefact*, 4(1).

Pesek, M., Klavž, F., Šavli, P., and Marolt, M. (2022). Online and in-class evaluation of a music theory e-learning platform. *Applied Sciences*, 12(14).

Pesek, M., Suhadolnik, L., Šavli, P., and Marolt, M. (2020a). Motivating Students for Ear-Training with a Rhythmic Dictation Application. *Applied Sciences*, 10(19).

Pesek, M., Vučko, Ž., Šavli, P., Kavčič, A., and Marolt, M. (2020b). Troubadour: A Gamified e-Learning Platform for Ear Training. *IEEE Access*, 8:97090–97102.

Petri, G., Gresse von Wangenheim, C., and Borgatto, A. (2018). MEEGA+: A Method for the Evaluation of Educational Games for Computing Education. Technical report, Brazilian Institute for Digital Convergence.

Saleem, A. N., Noori, N. M., and Ozdamli, F. (2022). Gamification Applications in E-learning: A Literature Review. *Technology, Knowledge and Learning*, 27(1):139–159.

Schrepp, M. (2015). *User Experience Questionnaire Handbook*.

Schrepp, M., Hinderks, A., and Thomaschewski, J. (2014). Applying the User Experience Questionnaire (UEQ) in Different Evaluation Scenarios. In *International Conference of Design, User Experience, and Usability*.

Schüler, N. (2021). Modern Approaches to Teaching Sight Singing and Ear Training. *Facta Universitatis, Series: Visual Arts and Music*, pages 83–92.

Sezer, E. and Temiz, E. (2023). Mobile Music Application-Supported Music Theory and Ear Training Education. *the Journal of Academic Social Sciences*, 11(136):26–37.

Urh, M., Vukovic, G., Jereb, E., and Pintar, R. (2015). The Model for Introduction of Gamification into E-learning in Higher Education. *Procedia - Social and Behavioral Sciences*, 197:388–397.

Wagner, C. (2017). Digital Gamification in Private Music Education. *Antistasis*, 7(1).

Woody, R. H. (2021). Music education students' intrinsic and extrinsic motivation: A quantsitative analysis of personal narratives. *Psychology of Music*, 49(5):1321–1343.