

Citation (APA)

Roa, E. R., Li, H., Martinez, J. C. J. R., Raave, D. K., Politimou, N., Colasante, T., Malti, T., Specht, M., & Mori, J. (2026). Play My Math: Design and Implementation of a Course Creator Tool Within a Mathematical Musician Digital Learning Platform. In K. Tammets, S. Sosnovsky, R. Ferreira Mello, G. Pishtari, & T. Nazaretsky (Eds.), *Two Decades of TEL. From Lessons Learnt to Challenges Ahead - 20th European Conference on Technology Enhanced Learning, EC-TEL 2025, Proceedings* (pp. 367-372). (Lecture Notes in Computer Science; Vol. 16064 LNCS). Springer. https://doi.org/10.1007/978-3-032-03873-9_51

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







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Play My Math: Design and Implementation of a Course Creator Tool Within a Mathematical Musician Digital Learning Platform

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Abstract. We present and describe one of the components of our mathematical musician platform, Play My Math, called the Course Creator Tool. Teachers can use this tool to integrate music in their pedagogy and create cross-curricular (i.e., music and mathematics) lesson plans. The current version of our Course Creator Tool works with eight modules (i.e., Description Block, Multimedia Block, Music Lab, Beat Maker, Fraction Lab, Music Generator, Fraction Generator suite, and Worksheet Demonstrator) that the teachers can freely organize and customize for their lessons. We have also created templates they can copy and modify to cover 17 subtopics of fractions. The need for a Course Creator Tool was derived from feedback given by teachers during a study we did in Mexico during the first quarter of 2024, and from UK teachers' feedback coming from an intervention done during the first quarter of 2025. By closely collaborating with teachers in our design-based research iterations, we aim to increase the educational value of the Play My Math platform, empower mathematics teachers' practice, facilitate musical integration into mathematics pedagogy, and ultimately progress towards a mathematical musician curriculum for K–12 education.

Keywords: STEAM education · cross-curricular approaches · mathematical musician curricula · music and mathematics · educational technology · fraction education · instructional design · technology enhanced learning

1 Introduction

Music and mathematics cross-curricular literature suggest that this educational approach is meaningful and promising for learning [1, 2]. However, and to the best of our knowledge, existing digital tools [1, 2] lack a holistic design where the teachers' technological,

pedagogical, and instructional expectations are met. To address this technological gap, we designed and implemented a Course Creator Tool (CCT) into our educational platform called Play My Math (PMM). PMM is a digital learning platform that enables mathematics teachers to integrate music into their pedagogy [3–5], and from there, use the tool to teach universal subtopics of fractions [5]. The teachers can use a series of multimodal modules to showcase the connection between music and mathematics using graphical representations (i.e., configurable bars and mathematical notations) and aural representations (i.e., playing back the resulting graphical representations and mathematical notations). For guiding our first CCT’s design and implementation cycle, we used Mexican teachers’ focus group data where they expressed the need to have a dedicated component on the platform where they could create and/or use ready-made templates to cover common subtopics of fractions [3]. Then, for the second design and implementation cycle, we enhanced our CCT using UK teachers’ feedback derived from a ten-week feasibility study done in collaboration with a primary school in London. In the next sections, we elaborate on our music and mathematics integration and cross-curricular rationale, describe how our CCT evolved and how it works, and we discuss our results and share some future research plans.

2 Theoretical Background

2.1 Cross-Curricular Education

The UNESCO International Bureau of Education has defined cross-curricular education as “an approach to formulating a curriculum that favors the dynamic use of learning topics and themes to be covered and skills/competencies to be developed in a number of learning areas across the curriculum” [6]. For instance, as a means to establish what is—or not—a cross-curricular scenario with music and mathematics, let us compare two approaches. In one approach, the teacher uses a song to which students could sing along to learn about fractions (i.e., lyrics including key concepts like unit or proper fractions, etc.). In the second approach, the teacher configures a group of bars—representing wholes—using a digital tool (e.g., the PMM Music Lab) to teach the students some common unit fractions (i.e., $\frac{1}{2}$, $\frac{1}{4}$, etc.), then, they can play back the resulting musical output and perform by clapping along to the desired active fractions. The second, interactive scenario is cross-curricular, while the first scenario is not.

2.2 Arts Integration

The Institute for Arts Integration & STEAM defines arts integration as “... an approach to teaching and learning through which content standards are taught and assessed equitably in and through the arts” [7]. In PMM, the teachers and students bypass the need of music theory (i.e., concepts and music notation) as they are invited to think, write, read, and perform music solely using mathematics (i.e., concepts and mathematical symbols). In PMM, music is directly the result of playing written mathematical notations (e.g., fractions, decimals, percentages) and graphical representations (i.e., bar configurations). Notably, there are some transcription nuances to consider between music and mathematical notations that teachers should be aware of while working with this cross-curricular

approach. In Fig. 1, we present this transcription nuances divided into “practical” and “confusion” cases.

Practical nuances between music and mathematic notations

Case 1. Same musical output in both musical measures

$$\frac{4}{4} \left| \text{Musical notation: four quarter notes} \right| 4\left(\frac{4}{4}\right) \left| \right.$$

Case 2. Multiple symbols for silence in music notation vs a single variable in algebraic notation

$$\frac{4}{4} \left| \text{Musical notation: three quarter notes and a whole rest} \right| 3\left(\frac{1}{4}\right) + \frac{S}{4} \left| \right.$$

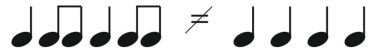
$$\frac{4}{4} \left| \text{Musical notation: quarter note, eighth note, eighth note, and whole rest} \right| \frac{1}{4} + \frac{1+S}{8} + \frac{1+S}{4} \left| \right.$$

Confusion nuances between music and mathematic notations

Case 1. Silence variable (S) potentially be confused with having a value of zero (i.e., absence of sound)

$$\frac{4}{4} \left| 3\left(\frac{1}{4}\right) + \frac{S=0}{4} \right| 3\left(\frac{1}{4}\right) + \frac{S=1}{4} \left| \right.$$

Case 2. Mathematical equivalence does not necessarily produce an equivalent musical output

$$\frac{1}{4} + \frac{2}{8} + \frac{1}{4} + \frac{2}{8} = \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$$


Case 3. Music notes' values changing dynamically when compared to the measure, bringing ambiguity to what their names stand for

$$\frac{4}{4} \left| \text{Musical notation: four quarter notes} \right| \frac{3}{4} \left| \text{Musical notation: three quarter notes} \right|$$

Fig. 1. Nuanced transcription cases in cross-curricular music and mathematics.

3 Method

Overall, we have been following a design-based research approach to develop the PMM educational platform. We have chosen this methodology as it considers multiple iterations to achieve the intended design goals [8]. Next, we describe the two development iterations which resulted in the current state of our CCT.

3.1 First Cycle: The Initial Prototype

As mentioned in the introduction section, the first version of our CCT was designed based on the teachers' feedback derived from our Mexican study done in the first quarter of 2024 [3]. In that occasion, teachers requested to have the possibility to create and/or use ready-made templates to cover typical subtopics of fractions with PMM. Back then, we focused on designing and implementing a section of the platform where the teachers could create their courses and lessons using the following modules: Description Block, Music Lab [3], and Fraction Generator suite [5].

3.2 Second Cycle: Enhancing the Course Creator Tool

Next, during the first quarter of 2025, and in collaboration with a UK primary school, two teachers delivered a ten-week fraction program using the PMM platform [4]. For each week of the intervention, we prepared template lessons for the experimental group covering the respective topics of fractions (as close as possible to the control group) but with the musical component, delivered in an online training to the teachers, and we then

received the teachers' feedback regarding the pedagogical experience and technological usefulness. During these feedback sessions, two researchers took notes of teacher's requests that we subsequently analyzed.

4 Results

The current version of the CCT is the result of weekly development cycles where we designed and implemented as many features as possible that we drew from the UK teachers' feedback sessions. The resulting CCT comprises of following modules: Description Block, Multimedia Block, Music Lab, Beat Maker, Fraction Lab, Music Generator suite, Fraction Generator suite, and Worksheet Demonstrator. Next, we further describe and categorize the above-mentioned modules.

4.1 Learning Content Management Modules

The teachers expressed the need for having modules allowing them to write and edit text, add links, and upload and manage common file formats (e.g., videos, images, audio, and PDF files). The Description and Multimedia Block allows them to achieve this.

4.2 Music and Mathematical Labs

Teachers expressed the need to have more control to create, save, and configure instances of the tools (i.e., modules) so they can better integrate music in their pedagogy, when teaching the subtopics of fractions (i.e., Music Lab, Beat Maker, Fraction Lab, and the Worksheet Demonstrator). On the musical side, the teachers requested the possibility of having music performance aids. Hence, we provided them with customizable syllables and body percussion coin-like tokens so that they could have a visual aid for guiding their students while performing music (Fig. 2). On the instructional side, the teachers requested a way to design and print their own PMM worksheets, and scaffold students when working with them. To address this feedback, we implemented the Worksheet Demonstrator, which enables teachers to bring the same type of visuals students see in activities to their worksheets for the sake of learning consistency.

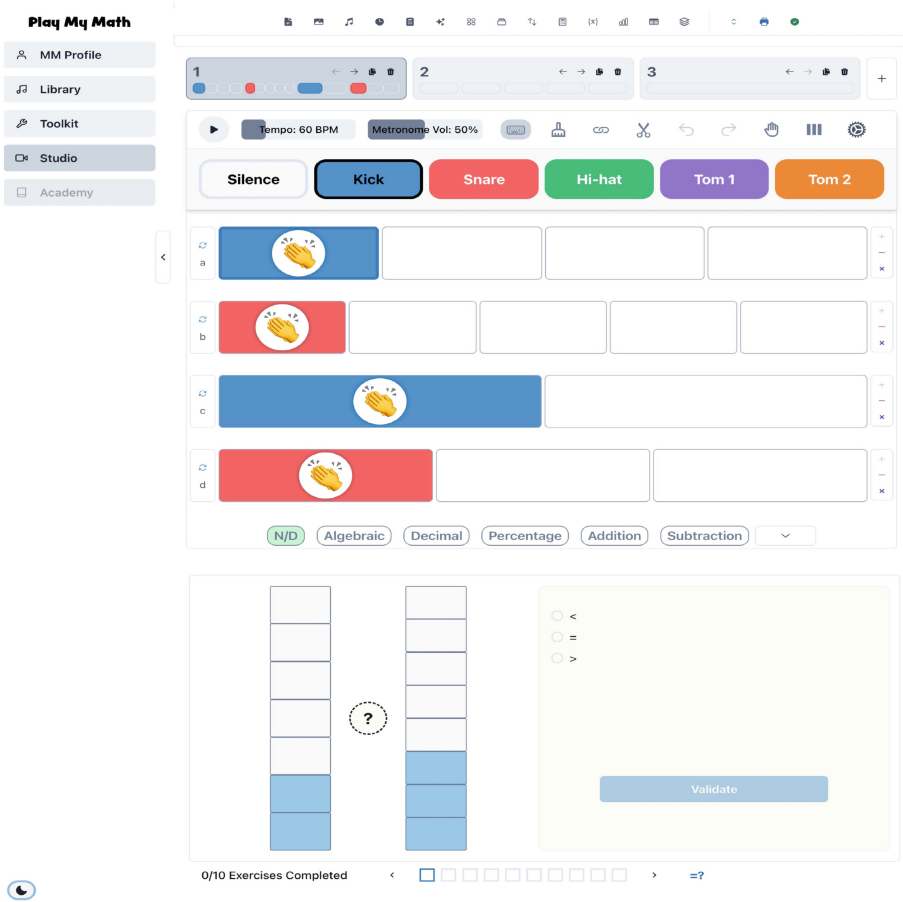


Fig. 2. PMM CCT examples of Music Lab and Fraction Generator instances.

4.3 Practice and Exercise Generators

The teachers requested to be able to create and integrate into the CCT on-demand formative and summative exercises covering the subtopics of fractions (i.e., identifying fractions, identifying notations, comparison of fractions, arithmetic applied to fractions, least common multiple, and quantity of a fraction). The teachers can now directly configure and incorporate exercises into their courses or lessons using the Music and Fraction Generator Suite (Fig. 2).

5 Discussion, Conclusions, and Future Work

In this paper, we have described two design and implementation cycles of a CCT that is one of the components of our proposed Mathematical Musician educational technology platform, PMM. In our CCT, the teachers can use a series of modules that enable them to manage learning content (i.e., Description Block and Multimedia Block), integrate music

into their pedagogy and further explain common subtopics of fractions (i.e., Music Lab, Beat Maker, Fraction Lab, and the Worksheet Demonstrator), and generate formative and summative exercises and assessments (i.e., Music Generator suite and Fraction Generator suite). We anticipate this CTT to make PMM a more robust teaching platform as it has been co-designed with teachers in a deeply iterative fashion. In future work, and in collaboration with a Brazilian primary school, we will evaluate how to sustain and improve our CCT and PMM in a new cultural and educational context.

Acknowledgments. The UK strand of this study was funded by British Academy's BA/Leverhulme Small Research Grants Programme (grant reference number: SRG2324\241835).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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