Article

International Journal of
Music Education
2014, Vol. 32(2) 242–260

DOI: 10.1177/0255761413517056
ijm.sagepub.com

In Harmony: A technology-based music education model to enhance musical understanding and general learning skills

Adena Portowitz
Bar-Ilan University, Israel

Kylie A. Peppler
Indiana University, USA

Mike Downton
Saint John's University, USA

Abstract

This article reports on the practice and evaluation of a music education model, In Harmony, which utilizes new technologies and current theories of learning to mediate the music learning experience. In response to the needs of twenty-first century learners, the educational software programs Teach, Learn, Evaluate! and Impromptu served as central components of the program's curriculum. Moreover, drawing on educational theories that value general learning skills as prerequisites to scholastic achievement, the In Harmony program provided a context in which students could improve their working memory, self-regulation, and cognitive flexibility. The model was adopted internationally in Bloomington, IN and Jaffa, Israel, and featured individual tasks administered through computer software, as well as group music composition activities. By incorporating computer technology within the program's design, and targeting the above-mentioned learning skills, we sought to strengthen the impact of the music lessons and deepen our understanding of the mechanisms linking music education and enhanced cognitive development. Quantitative and qualitative evaluation of the children's working memory, self-regulation, and cognitive flexibility, as well as qualitative analyses of data collected during the intervention, indicated that the In Harmony model and the educational software used successfully scaffold musical instruction, with beneficial outcomes in fostering working memory, self-regulation, and cognitive flexibility.

Corresponding author:
Adena Portowitz, Amir Institute for Social Integration in the Schools, Department of Education, Bar-Ilan University, Ramat-Gan, 52900, Israel.
Email: Adena.portowitz@biu.ac.il

Keywords
mediated music education, computer technology, general learning skills, working memory, self-regulation

Music education today seeks to respond to the changing demands of twenty-first century learners. Today's children are living in an environment saturated with new technologies, which are vastly changing the landscape of teaching and learning (Gooden, 1996). Thus, for example, new technologies have made it possible for even the most novice of composers to write music with software like Apple's GarageBand (http://www.apple.com/ilife/garageband/). Despite such affordances, music educators have been hesitant to incorporate new technologies in their classrooms (Savage, 2007), creating a need for more comprehensive models that integrate technologies relevant to a wide range of learners (Webster, 2007). Moreover, such models will be expected to promote high-quality educational outcomes, such as improved musical understanding and general learning skills, known to be staples of excellence in many music education curriculums (Hallam, 2010).

The In Harmony program proposes a model for music education in which computer technology and current theories of education mediate the learning experience and broaden the practices of traditional music instruction (Nir-Gal & Klein, 2004). Informed by prior research on music and technologies (Bamberger, 2000), and the potential impact of music education on enhancing learning skills and scholastic achievement (Hallam, 2010; Portowitz et al., 2009), we further researched the proposed model by evaluating its effectiveness in two international settings, in the US and in Israel. In both localities, we looked at whether and to what extent the model influenced the children's musical understanding and contributed toward improved general learning skills. Intimately connecting between practice and evaluation, the music teachers and researchers collaborated in designing, implementing, assessing, and redesigning the music tasks in response to what was happening in the classroom (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003).

In Harmony model

The In Harmony music education model, suitable for elementary school children, aimed to create a multi-layered enjoyable musical experience, in which children could improve their musical understanding while developing select learning skills (e.g. working memory, self-regulation, and cognitive flexibility, which are further defined below). Seeking to take advantage of young people's interest in new technologies, the In Harmony program incorporated two music-education software programs, Teach, Learn, Evaluate! and Impromptu, which were chosen because of their compatibility and specific affordances in mediating learning.

The Teach, Learn, Evaluate! (TLE) software consists of a series of exercises, administered online, featuring a scaffolded sequence of musical activities. Designed and constructed at the Amir Institute for Teaching, Learning & Social Integration at Bar-Ilan University, in collaboration with DP-Multimedia Information Design, Beer Sheva Israel, the musical objectives of the exercises are coordinated with Israel's National Music curriculum for elementary school grades 1 to 4.

Impromptu (Bamberger, 2000) features a user-friendly environment, in which computer-based composition projects enable learners to engage in a closer active listening and meaning-making process in the reconstruction and remixing of well-known tunes. The objectives of these projects are to promote a deeper understanding of melodic structure and form, rhythm and meter, pitch, and harmony, and to provide an active context in which the students learn how these elements combine

in the composition of coherent musical structures.[1] Administered in conjunction with the TLE exercises, the Impromptu software provides an additional framework in which students can implement and deepen their newly acquired musical understanding through composition and reflective writing.

The theoretical underpinnings of the In Harmony model. The theoretical premise of the In Harmony program drew on components of Feuerstein's theory of structural cognitive modifiability (SCM) and mediated learning experiences (MLE)[2] (Feuerstein, Feuerstein, Falik & Rand, 2006; Feuerstein, Rand & Rynders, 1988), Klein's *M*ore *I*ntelligent and *S*ensitive *C*hild (MISC) pedagogical approach (Klein, 1996), and Diamond's theory of executive functions (Diamond, 2007). In line with this approach, they defined and codified general learning skills that acted as prerequisites to scholastic achievement. Research confirmed that when these learning skills function well, children generally achieved better results in and out of school (Davidson, Amiso, Anderson & Diamond, 2006; Diamond, 2007; Feuerstein et al., 2006; Feuerstein et al., 1988).

While these learning skills were context-free, several of them bore a similarity to the cognition involved in the deeper perception of components in music (Portowitz & Klein, 2007; Portowitz, Lichtenstein, Egorov & Brand, 2009), and were targeted for development in the In Harmony program. These included:

- Working memory – a skill that makes it possible for a person to remember instructions and to consider alternatives when completing a task. Working memory is critical to a person's ability to see connections between seemingly unconnected items and to separate elements from an integrated whole. Thus, an active working memory helps children learn to compare, organize, and categorize multiple pieces of information (Diamond, 2006), and is particularly important for developing reading comprehension skills (Berchin, 1991; Kreiger & Kaplan, 1990). Applied to In Harmony, the TLE and Impromptu music analyses and composition exercises challenge children to recall and categorize musical sounds, to identify features in music that generate functional boundaries, and to understand how entities at different hierarchical levels of structure relate to one another. Understanding such large-scale organizing structures nurtures an active working memory.
- Self-regulation – this function enables children to ignore distractions and to resist making one response rather than another (Diamond, 2006). By 'thinking before doing,' children are in a better position to choose the best strategies needed to successfully complete a task. Applied to In Harmony, engaging in attentive listening, composing, and performing helps children refrain from impulsive behavior while they work alone or together with their fellow classmates. Moreover, the TLE software recorded the mouse-movements as the children completed the exercises, providing the teacher and researcher with data that reflected on the children's working habits and ability to 'think before doing' while completing the exercises (further explained below).
- Cognitive flexibility – the ability to flexibly switch perspectives and draw on past experiences in new ways offers children verbal and non-verbal means through which to convey their ideas (Diamond, 2006). Applied to In Harmony, the computer software provided opportunities for children to document the musical features that they particularly notice and choose to recall, and to translate their musical understanding into aural, kinesthetic, and graphic modes of representation (Bamberger, 1991; Brand, 1997; Cohen, 1997; Gruhn & Rauscher, 2002). The subjective nature of this process becomes evident when comparing children's different representations of the same piece, demonstrating the many options that

exist for expressing musical understanding. This learning process encourages cognitive flexibility.

In addition to defining and codifying these learning skills, Feuerstein and Klein propose a pedagogical approach that is particularly conducive to the development of these learning skills (Feuerstein, Klein & Tannenbaum, 1999; Klein, 1996). Referred to as mediated learning experiences (MLE), this pedagogical approach nurtures active interaction between the teacher and the students, during which time the teacher probes the child's understanding, lends meaning and excitement to the lesson, and expands a given situation to apply what is being learnt to new situations.

Method

Overview of the settings, participants, and activities

The In Harmony model, supported by the Fund for the Advancement of Peace and Education, University of Indiana, and the Institute for the Advancement of Education in Jaffa, was implemented jointly in two school settings with the participation of 9- to 10-year-old children, in an urban area of Tel Aviv, Israel ($n = 62$) and in a medium-sized Midwestern city in the US ($n = 22$). This article focuses on findings obtained from the Israeli research group. For a discussion of findings based on the American research group, see Downton, Peppler, Portowitz, Bamberger & Lindsay (2012).

After carefully reviewing the curriculum and research design of the In Harmony program, the Ministry of Education in Israel granted permission to conduct the program in the chosen school during school hours. The Israeli children were divided into two groups: 40 children constituted an experimental group while 22 children, matched in age, socio-economic status, and school setting, comprised an Israeli control group. During the class sessions, the Israeli research group subdivided into two groups of 20 participants each.

The In Harmony program operated over a four-month period, during which each student attended two hours per week; overall, each student received 32 hours of music training during the program's duration. Each location included a computer laboratory; all of the computers were equipped with TLE and Impromptu software. The computers were arranged around the walls, while a large table was positioned in the middle of the room, enabling the students to gather together for group discussions and activities after completing the computer tasks. Two certified music teachers (a main teacher and an assistant) and one researcher attended each class.

As a prerequisite for the success of the program, the music staff coordinated schedules, objectives, and technical assistance with the head master of the school and classroom teachers. Creating and maintaining a good working partnership with the school was imperative for the success of the program. In addition, letters were sent to the participants' parents, informing them about the In Harmony program, and asking for their consent to periodically film select lessons.

The curriculum subdivided into four large units dedicated to the TLE exercises and Impromptu composition tasks, and a final concluding project. Each session included two 50-minute lessons. During the first lesson, the teacher explained the TLE or Impromptu task for that day, after which the children worked individually with the computer software. During the second lesson, the children gathered around the large table for discussions about their work and additional group activities. The group lessons, conducted as mediated leaning experiences, provided unique opportunities for sharing ideas, performing, and reflecting. During these lessons, the music teachers maintained

active interactions with the children, focusing their attention on the learning task, conveying enthusiasm, defining and introducing new musical terms, and expanding the immediate learning context to include new musical examples as well as relevant non-music materials.

Teach, Learn, Evaluate! exercises

Having reviewed the overall context of the In Harmony program, we further explain the organization of the TLE and Impromptu computer programs. The computer-based program, Teach, Learn, Evaluate! currently consists of four interactive exercises administered online, in which children complete graphically attractive musical tasks designed to foster musical understanding as well as general learning skills. Narrating the exercises, a friendly voice mediates between the child and the tasks, explaining terms and conveying excitement and support.

The TLE software exercises develop progressively. Each exercise begins by focusing the children's attention on a general concept. It then continues to explore this concept within a musical context, and concludes with tasks in which the children apply and expand what they have learned in a new context. The first exercise, for example, based on the tune "Frère Jacques," opens by explaining what we see in mirrors. The exercise continues with activities that call attention to the melodic contour and structural organization of the tune, followed by tasks that demonstrate how students may convey their musical understanding by using a variety of different methods of representation.

Using kinesthetic hand gestures, referred to as "musical mirrors" (Cohen, 1997), as well as graphic and pictorial symbols, the children practiced recalling and making sense of the song's structure and melodic contour (working memory), and applying this understanding in vastly different contexts (cognitive flexibility). Thus, in one screen, the children analysed the song while viewing bouncing balls, whose color changed as the melodic motives changed (Figure 1(a)). This task was followed by two short video clips, in which the children viewed musical mirrors. The children were asked to choose the video that best represented the song – and to explain why. Moving on to a more abstract task, the children were asked to arrange geometric forms on a line in a sequence that represented the musical structure of the song (Figure 1(b)). The children also were asked to match different fragments of the tune with appropriate graphic representations (Figure 1(c)) and to design their own representation of the "Frère Jacques" tune. The exercise concluded with an explanation of musical canons. During the composition and group tasks the children composed their own canons using the Impromptu tuneblocks, analysed additional musical canons, and performed canons using simple musical instruments, movements, and voices. TLE 2 focused on strophic forms and on cooperation in music and non-music contexts. TLE 3 focused on program music and dialogue in music, while TLE 4 focused on recognizing, composing, and documenting short tunes in ABA forms, and creating musical games and puzzles based on graphic representations of short musical pieces. For an overview of the content, structure and learning skills promoted within the TLE exercises 1 to 4, see Table 1.

Impromptu

On completion of each of the TLE exercises, the children reconstructed and composed tunes using the Impromptu software. The two programs complemented one another, as students were encouraged to implement and expand on the knowledge obtained in the TLE exercises in their compositions.

When opening the Impromptu software, users are presented with three main areas of focus (Figure 2).

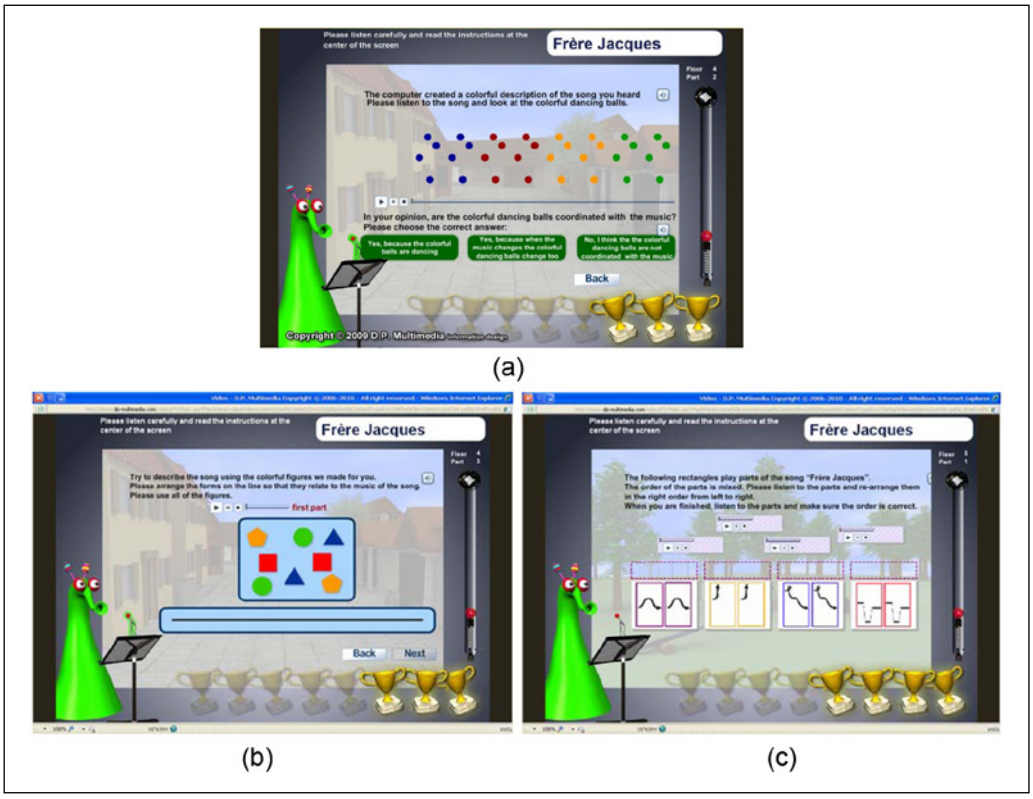

Figure 1. Multiple ways of representing the tune "Frère Jacques" in TLE.

The first is along the right side of the interface, where tuneblocks for a particular tune are housed. Tuneblocks are structurally significant segments of larger melodies that constitute the primary tool in Impromptu. The tunes included in our Impromptu program draw on melodies representing Western, Chinese, and Arabic traditions. Each tune contained a block that plays back the entire tune (the 'All' blocks in Figure 4), as well as patterned blocks that contain the audio file and visual representations of segments of the tune. Once the user feels more familiar with each pattern in the tune, s/he can reconstruct the original tune or compose a new tune by grabbing and dropping the tuneblocks in the playroom.

The playroom is where users put the tuneblocks in any order they like. By tagging the contents of each tuneblock onto the end of the previous one, the graphics area 'summarizes' the sequence of tuneblocks in the playroom, creating a complementary mode of notation that documents pitch and duration.

Finally, along the bottom-left side of the screen is the notebook, a miniature word-processor, which allows users to keep notes of the steps taken in making their composition. Due to language constrictions, the Israeli children documented their observations in an accompanying reflective log. The children's reflections addressed issues such as the contour of a melody, its expression, and its function within the larger tune (e.g. beginning, middle, or ending material) (Downton et al., 2012).

For an overview of the content, compositional tasks, reflective analysis and creative tasks addressed using the Impromptu software, see Table 2.

Table 1. Outline of the general and musical content, learning skills, and creative and applicative tasks addressed in the four TLE exercises.

Exercise number	Music	General concept	Musical content	Learning skills	Creative and applicative tasks
1	"Frère Jacques" (French folksong)	Different types of mirrors; different uses of the mirror	Familiarity with the 'musical mirror'; recognizing repetitions in music; simultaneously listening to two voices; learning the concept of 'canon'	Working memory: developing the ability to compare. Cognitive flexibility: various ways of representing relationships of repetition, variation, and changes in the song's phrases	Cognitive flexibility: creating a personal mirror; personal description in symbols of the song's structure; Working memory: 'composing' a song in the form of "Frère Jacques"
2	"Three Strings and a Needle" (Words: A. Hillel; Music: Alexander Argov)	Developing the theme of 'cooperation'	Importance of communication: understanding the relationship between melody and words; learning the concept of 'strophic structure'	Cognitive flexibility: developing the multiple representation of text/music relationships	Cognitive flexibility, working memory: creating a colorful tapestry on the computer that integrates multiple colors and forms information within a coherent whole, identifying strophic structures in new songs
3	"Fife and Drum" (André Hajdu)	The general concept of 'contrast'; the general concept of 'imitation'	Understanding 'contrast' and 'imitation' in music	Working memory: comparison; simultaneous categorization of information	Working memory: completing missing portions in graphic notation based on coordinating between graphic representations and musical motives
4	"Game" (Bela Bartók)	Reference to the work's title as an external description of its character; the compatibility between a name or a title and the music's character	Different types of mirrors; different uses of the mirror	Working memory: comparison; representation; perceiving the whole through an understanding of the relationships between the parts	Working memory, cognitive flexibility: Putting together a jigsaw of the new song's map (graphic notation); identifying ABA structure in a new work

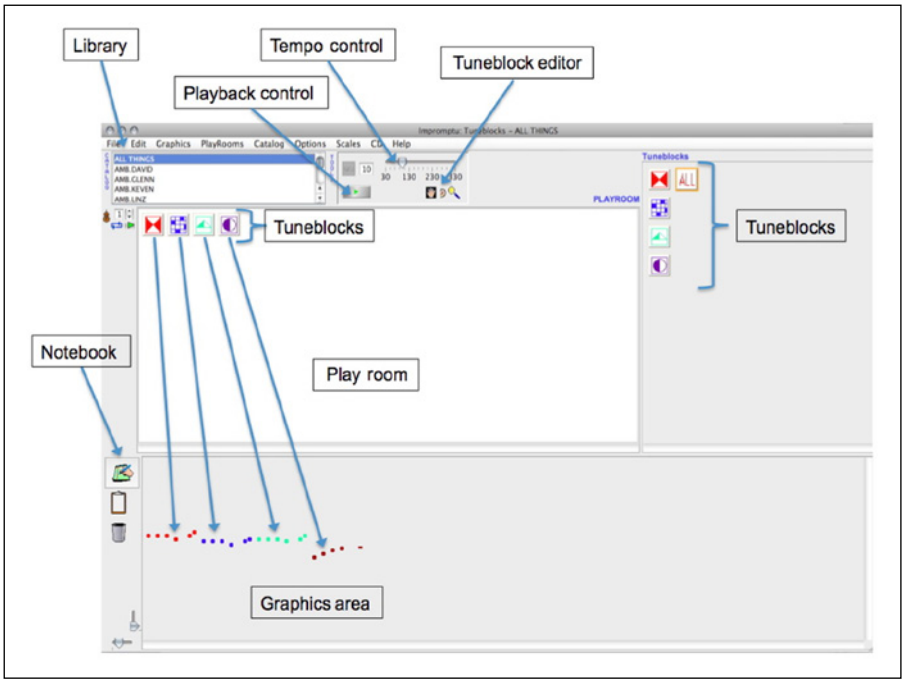

Figure 2. Screenshot of the Impromptu software, with relevant tools labeled.

Evaluation

In line with the objectives and theoretic framework of the In Harmony program, the assessment component of the In Harmony program addressed the following questions:

1. What and how will youth learn about music through their experiences with the computer-based TLE and Impromptu musical learning instruments?
2. Will children who participate in the In Harmony program significantly improve their working memory, self-regulation, and cognitive flexibility?

To answer these questions, both quantitative and qualitative data were collected.

Quantitative evaluation. Working memory was assessed quantitatively using the Rey Complex Figure test (Meyers & Meyers, 1995), administered pre- and post-intervention. This test evaluates children's ability to copy and draw a complex figure from memory (see Figure 3). The 'complex figure' consists of 18 items. Specifically, working memory is assessed by having the participants view the figure and copy it down. Once that is completed, the figure is removed from the participants' sight and they are asked to draw the figure from memory.

For scoring, each item that appears in its correct position in the child's drawing earns two points. Validity for this tool was established by Meyers and Meyers (1995) and in a simplified version for young children by Tzuriel (2001).

To quantitatively evaluate the changes from pre- to post-intervention in the working memory of the participants, a multivariate analysis of variance (MANOVA) was used. The MANOVA is most

Table 2. Outline of the content, compositional tasks, reflective analysis and creative tasks addressed using the Impromptu software (Bamberger, 2000, pp. 6–57).

In conjunction with TLE exercise	Melodies contained in tuneblocks	Compositional tasks	Reflective analysis	Creative tasks
1	"Lassie," "Hot Cross Buns," "Little Jonathan"*	Reconstructing a given tune by putting a given set of tuneblocks in a specific order	What musical features (e.g. repetition, contrast) create boundaries that delimit the structural elements we hear? How might these differ from one person to another? How can the same tuneblock convey different melodic functions? What is a melodic sequence?	Composing new tunes that feature repetition and contrast. Creating a sequence and a canon. Creating, identifying, and representing ABA structures in multiple modalities. Representing tunes and canons in multiple modalities. Creating graphic representations of "Frère Jacques."
2	"Austrian," "Susanna," "Early," "Ode," "Twinkle, Twinkle Little Star," "Eliyahu"*	Reconstructing a given tune by putting a given set of tuneblocks in a specific order	How can we differentiate between opening, middle, and closing functions in our tunes? What creates structural hierarchies?	Creating and identifying strophic, variation, and refrain structures. Creating tunes that feature specific compositional strategies by rearranging the tuneblocks of a given tune.
3	"French," "English," "Arabic Song # 1"*	Creating new tunes using a given set of tuneblocks.	Which blocks seem to go well together and why? How can we decide which block is most suitable for beginning, middle, and ending functions?	Experimenting with different types of contrast.
4	"Chinese," "Arabic Song #2"*	Creating new tunes using a given set of tuneblocks. Differentiating between open, closed, strong, and weak articulations. Creating symmetric and asymmetric melodies. Creating dialogue in music	What extra-musical ideas can we convey by juxtaposing contrasting motives? Identifying when and why we chose to use repetition, sequential relations, or antecedent-consequent phrase relationships in our tunes.	Composing tunes that feature dialogue. Creating games based on identifying, and representing various musical structures in multiple modalities.

* We thank Jeanne Bamberger for adding these tunes to the tuneblock library.

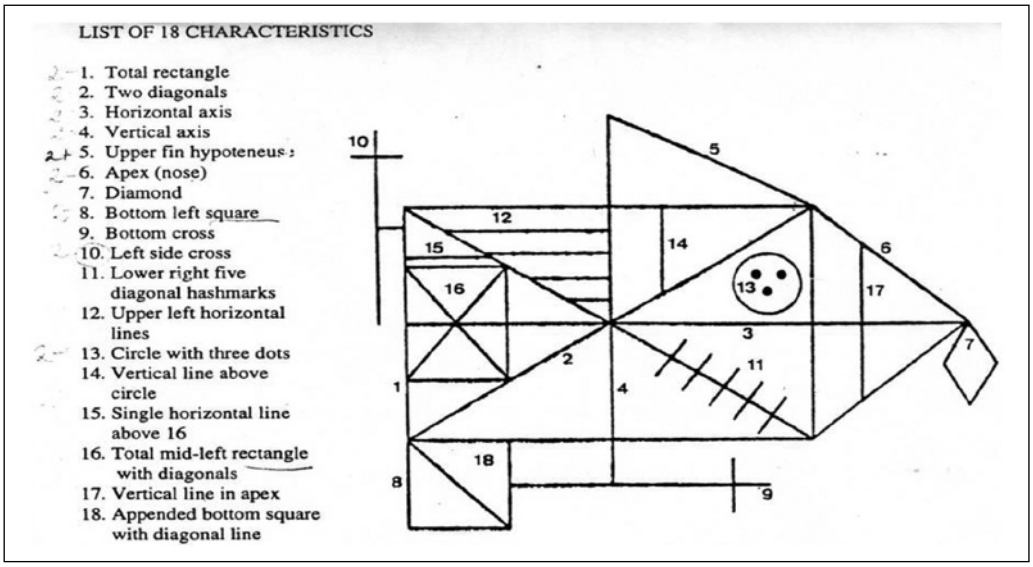

Figure 3. The Rey Complex Figure test with list of 18 characteristics. (Feuerstein et al., 2003)

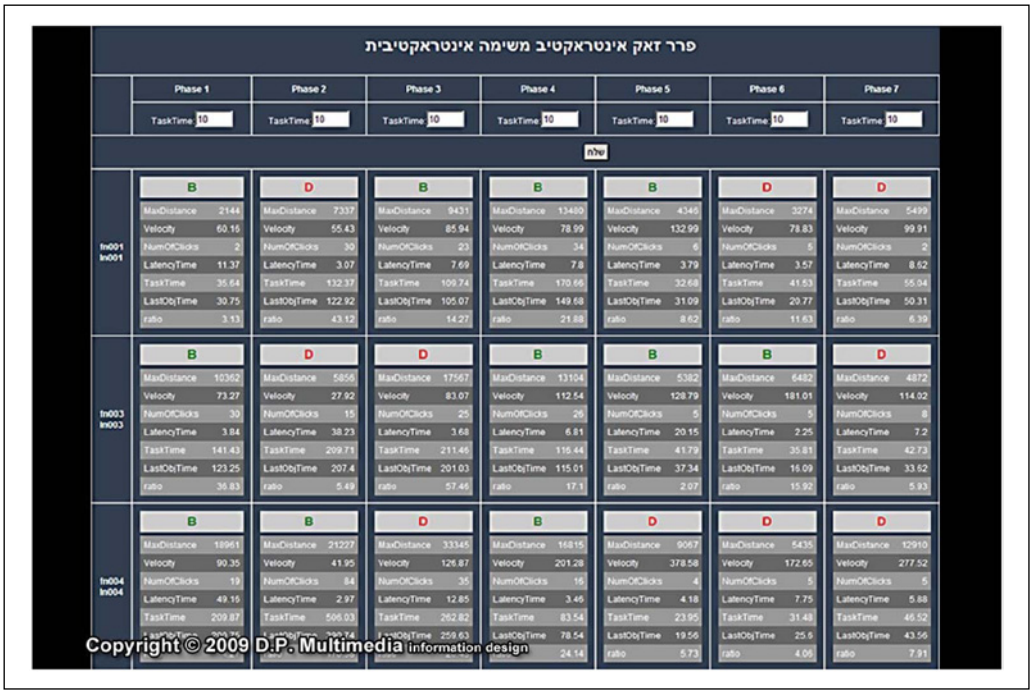

Figure 4. Record of mouse-movements recorded in real time while the child engages in TLE tasks. Published with permission of D-P Multimedia Information Design.

appropriate here because of the investigation of two related dependant variables (groups and time) and thus being able to control for any correlations between the two. The Israeli participants (research and control groups) and the American research group were assessed using this test. Assessing these groups enabled us to evaluate the impact of the In Harmony program on the working memory of the two very different research groups (Israeli and American), and to compare these results with an Israeli control group who did not participate in the program. Including both American and Israeli data strengthened the validity of the model.

Qualitative evaluation was represented by five types of data. First, the drawings of the Rey's Complex Figure were analysed qualitatively. An interesting caveat to the Rey Complex Figure test is that participants are given four colored pencils and told to switch colors approximately every 60 seconds (Feuerstein, Feuerstein, Falik & Rand, 2002). Analysis of the colors used in the drawing enables the researcher to note what the child copied first, second, etc. and to identify a working strategy. Understanding this process enables the tester to evaluate the following parameters:

1. Self-regulation, evidenced by the child's ability to organize and structure a complex field while copying the complex figure;
2. Cognitive flexibility, assessed by evaluating the processes used in structuring and organizing the complex field.

Second, musical understanding was demonstrated by a drawing task, in which the children documented their recollection of the salient musical features of a tune studied in class. This task also provided information regarding the children's working memory and cognitive flexibility.

Third, the children maintained reflective logs in which they explained the rationale behind their compositional choices.

Additionally, self-regulation was measured using a special feature of the TLE software that records the mouse movements as the child completes an exercise. Providing a unique glimpse into the working habits of the children, this data provides information regarding the number and locations of the mouse clicks, the total time spent working on each exercise, and the time that elapses between when the child first sees the task and when active engagement begins (see Figure 4). Thus, fewer and more carefully placed mouse movements and a longer time span between the first viewing of the exercise and actually beginning to work on it appear to indicate self-regulation and active working memory skills.

Finally, references to informal conversations with the students are included, to further substantiate the evaluation of the program from the child's perspective.

Results

The findings presented below provide quantitative and qualitative evidence of the children's musical understanding as well as a growing facility in their working memory, self-regulation, and cognitive flexibility skills.

Evaluating working memory with the complex figure test

Our hypothesis suggested that after intervention, the children in the experimental groups would show improvement on the results of their evaluations, and that the Israeli experimental group would show greater improvement than the Israeli control group. To evaluate the differences, we

Table 3. Mean and standard deviations of values obtained pre- and post-intervention for copied and memory drawings by the American and Israeli experimental and the Israeli control groups.

Group	Number in group (*n*)	Drawing test	Pre-intervention		Post-intervention		F
			M	SD	*M*	SD	
Experimental, America	22	Copy	30.30	5.88	34.15	1.73	11.16**
		Memory	24.45	7.78	32.65	2.91	26.92***
Experimental, Israel	40	Copy	26.37	5.79	29.51	5.6	8.17**
		Memory	16.05	8.63	19.60	7.66	6.21**
Control, Israel	22	Copy	24.19	7.09	25.67	8.52	10.89**
		Memory	17.62	7.88	15.81	8.38	0.95

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

conducted an analysis, both pre- and post-intervention, using two variants: copying (which required little to no working memory) and memory. The pre-intervention measurements showed no significant differences between the experimental group and the control group [$F(2,59) = 2.62$, $p > 0.05$]. Post-intervention, MANOVA 2 × 2 (groups × time) with repeated measures for time revealed that groups × time interaction was significant [$F(2,59) = 3.66$, $p < 0.05$; $\eta^2 = 0.11$] (see Table 3).

The results indicate a significant post-intervention improvement in memory measurements in the American and Israeli experimental groups. Memory scores in the control group did not improve over time, and even declined slightly.

Evaluating self-regulation and cognitive flexibility with the complex figure test

Qualitative assessments of self-regulation and cognitive flexibility were demonstrated by analysing the individual pictures of each child. The following examples of child A's drawings illustrate what this looks like for an individual child. Figure 5 presents examples of child A's complex figure drawings, documenting: (a) pre-test copy of the complex figure; (b) pre-test memory drawing of the complex figure; (c) post-test copy of the complex figure; (d) post-test memory drawing of the complex figure. The pre-intervention drawings indicate that the child drew elements of the picture as s/he noticed them, without attempting to interconnect them in any way. When faced with the memory task, the child's picture featured a sporadic kaleidoscope of unconnected fragments that s/he remembered.

The post-intervention drawings reveal improvements in the child's organizational strategies, which enabled him/her to better recognize a large-scale structure and place the remaining graphic representations correctly within it. Beginning with a green crayon, the child drew a large square, which s/he then subdivided into sections. When s/he changed to the red crayon, s/he went on to fill in the details of the figure. This strategy indicated an improved self-regulation, as the child conceived a working strategy. Moreover, identifying the geometric forms within the complex figure indicated cognitive flexibility. Based on this strategy, the child was able to accurately reconstruct the complex figure from memory. This type of work recalls tasks from the In Harmony program, in which the children analysed given tunes and then recalled them using graphic and kinesthetic representations.

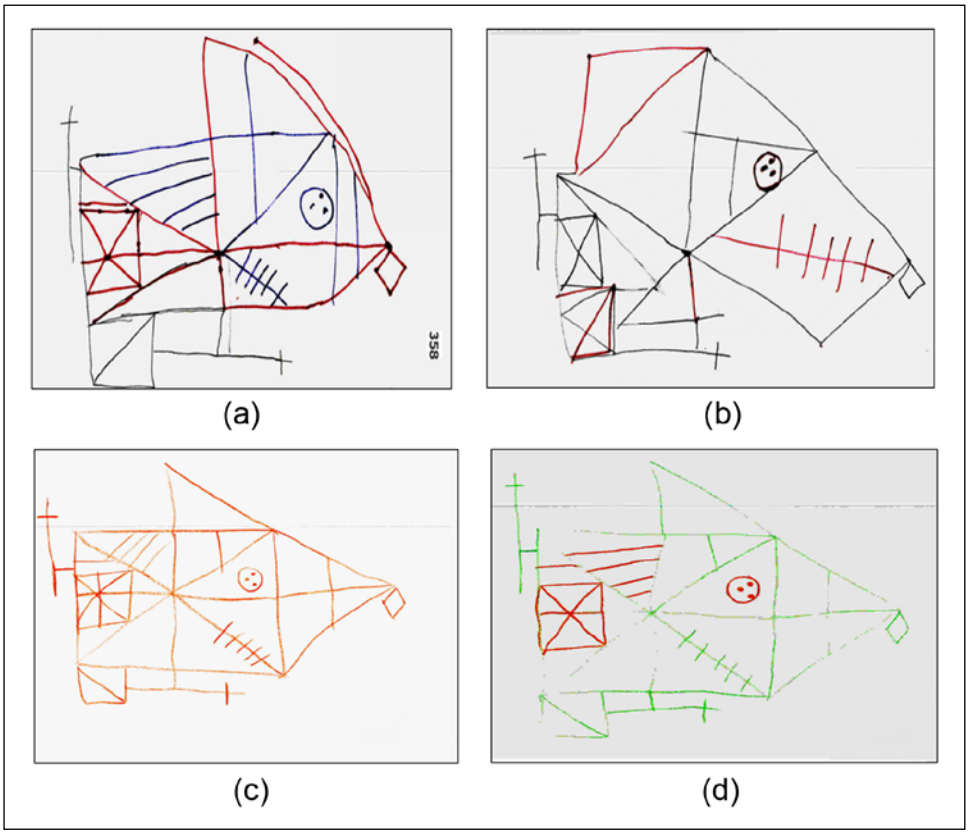

Figure 5. Child A's drawings of the Rey Complex Figure, pre- and post-intervention. (a) Pre-test complex figure copy; (b) pre-test complex figure memory; (c) post-test complex figure copy; (d) post-test complex figure memory.

Evaluating musical understanding using a drawing task

Figure 6(a), (b) and (c) illustrate sample graphic representations of the song "Frère Jacques," by three children after they had completed working on TLE exercise 1. The children were asked to represent on paper the tune that they had just heard. While each of the three representations documents elements of the song's structure (points of articulation, use of repetition, and contrast), indicating their musical understanding, they differ in what the children noticed and decided to record.

In Figure 6(a) the child indicated each note of the song by a short line. In addition, he introduced vertical figures articulating where repetitions of the material began. Thus, the child compartmentalized the individual notes according to repeated units.

In Figure 6(b), the graphic representation is contained within a large circle. This circle seems to infer a global perception, in which the individual parts are subsumed within a larger whole. Like student 1, student 2 also represented each note of the tune, in this case using circles. Unlike student 1, however, student 2 did not indicate repetitions. Instead, student 2 related to structural characteristics of the melody. Thus, larger circles document a melodic rise in the second motive and short lines represent rhythmic acceleration in the third motive.

In Figure 6(c), student 3, like student 1, represented each of the song's notes with lines. Resembling student 2, student 3's graph acknowledges the melodic rise in the second motive using

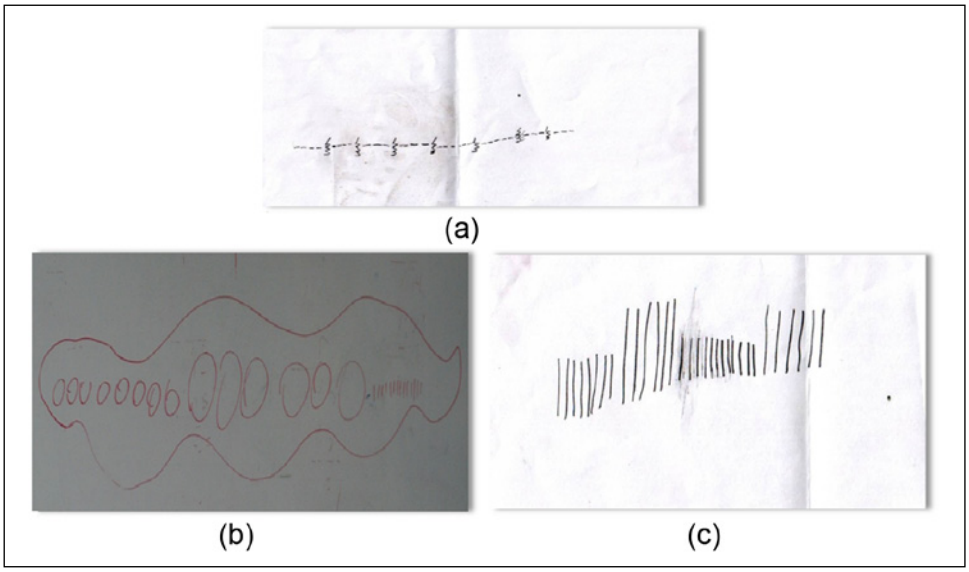

Figure 6. Representing melodies using different representational forms. (a) Graphic representation 1 of the song "Frère Jacques"; (b) graphic representation 2 of the song "Frère Jacques"; (c) graphic representation 3 of the song "Frère Jacques".

longer and higher lines. Student 3's graph is impressive in its representation of the tune's overall structure. Thus, the graph subdivides into two sections, each one containing two motives. Indicating the 'opening' function of motives 1 and 3, student 3 uses lines of similar length and height, despite the fact that they differ melodically. Similarly, she uses longer lines for motives 2 and 4, which function as closing motives. By choosing similar symbols to represent opening and closing materials, student 3 analyses the function of the motives, irrespective of their melodic or rhythmic content.

Displaying and analysing these artifacts during group discussions enabled the students to better understand and accept alternative representations of the tune. Indeed, during these discussions, the teacher focused the children's attention on the similar and different aspects of the drawings, and helped them to better understand how their peers perceived the musical structure and how they chose to represent it. Thus, while promoting musical understanding, these discussions also enhanced their cognitive flexibility and self-regulation skills. Moreover, reflecting on the In Harmony experience, children noted in informal interviews conducted at the end of the program that they particularly enjoyed tasks in which they worked with their friends and analysed tunes from different places.

Evaluating musical understanding using music composition and written reflection

Supplementing the activities of the TLE exercises, the students composed short tunes using the Impromptu software. As noted above, these tasks involved reconstructions of given tunes as well as free compositions. In addition to arranging the tuneblocks, the students also documented their compositional choices in personal reflective logs. The following text serves as an example of an Israeli child's reflections while composing an Arabic song entitled, "I am Writing to My Beloved." While the song is well known among Arabic-speaking children, these children were not familiar with the original song (score appears in Figure 7), and therefore arranged the tuneblocks as a free-

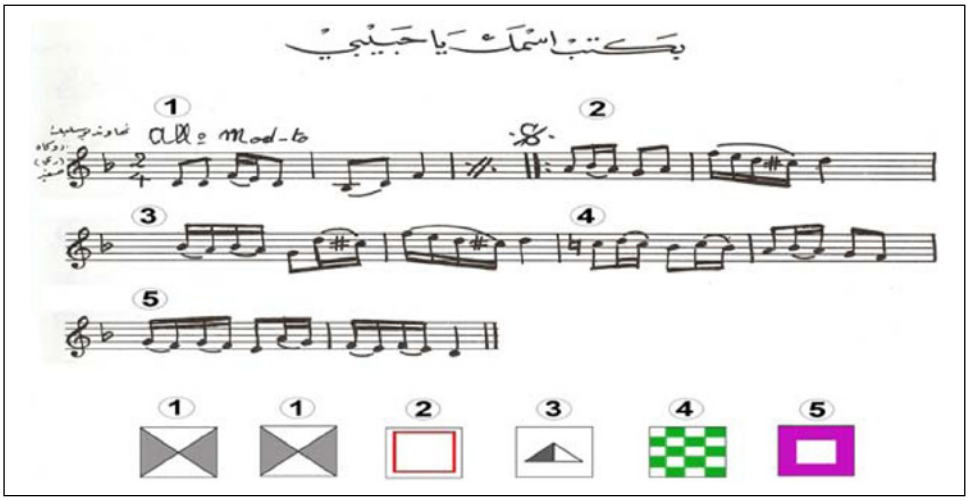

Figure 7. Score of the song: "I am Writing to my Beloved".

composition exercise (see blocks 1–5). The children worked on this task after completing the second TLE exercise.

A review of the student's log (Table 4) indicates that this child chose to arrange the tuneblocks according to their musical function. Thus, tuneblock 1 opens the tune and is repeated "because it sounded like a nice beginning." Tuneblocks 2 and 3 follow, because they sounded like continuations, while tuneblocks 4 and 5, repeated twice, concluded the melody, because they seemed suitable for an 'ending.' In categorizing the opening, continuing, and closing functions, the child explained that a rising melody was suitable for a middle section, while a descent signaled an ending. Changes in melodic contour, therefore, served to articulate the melodic function, while repetitions strengthened the sense of conclusion. These comments indicate a growing understanding of the constructs involved in musical composition, and are based on procedures addressed in TLE exercises 1 and 2.

By recalling previously learnt compositional strategies and applying them to a new context, the child demonstrated an active working memory and cognitive flexibility. Attesting to an overall growing sense of competence, many children explained in informal conversations that the composition tasks made them "feel like composers" and helped them "enjoy hearing tunes that initially sounded different."

Evaluating self-regulation using mouse movements

The TLE software saves video recordings of the movements of the computer mouse as the children work in real time. In the following examples, analysis of the mouse's movements enabled us to follow changes that occurred in child C's working habits. For task 1, the children were asked to listen to the song "Frère Jacques" and arrange colorful geometric figures on a line in a way that would represent the sequence of the song. The children were allowed to use the same geometric forms twice to indicate repetition. Observing the video recording of the mouse movements, we noted that child C began to move the geometric figures before having time to listen to the song, reflecting much activity but no strategic planning (Figure 8(a)). By contrast, Figure 8(b) documents child C's working habits recorded while engaging in exercise 3. Here, child C was asked to

Table 4. Child B's reflections on composing the song "I am writing your name as to my beloved". Child B composed his own song without previous knowledge of the original.

Child B's comments on his 'Arabic' tune	Researcher's comments
"I chose the grey one with the two triangles because it sounded like a nice beginning."	He seems to have been relating to the contour of the melody.
"I repeated this block because this sounded like a stronger beginning and reminded me of the repeats we heard in 'Frère Jacques'."	Child B drew on a universal pattern, which he had become aware of in his work on the tune "Frère Jacques."
"I then chose the grey block with one triangle because I wanted the melody to go higher."	Beginning the middle section of the song, he chose to change the melodic contour with a rise in register.
"Then I chose the red block because its melody was also high."	As in the opening, here too he preferred to work in complementary units of two.
"After this, I chose the green block because I wanted the melody to go down."	Feeling that it was time for a change, he balanced the rise in melody with a complementary descent.
"The purple block sounded like an ending because its melody goes down."	Like many of the other children in the program, he chose to end his piece with a descending, closing motive.
"I then repeated the green and the purple blocks so that I would have a strong ending."	The closing section was also repeated twice, complementing the opening and middle sections.
"I don't know other melodies that sound like this one and I think that the melody sounded sad."	Child B was not familiar with Arabic songs. However, he felt that the melody sounded sad, perhaps because of its minor mode and rhythmic retardation at the end.

Figure 8. Mouse movements recorded in real time. (a) Computer **mouse movements** of **child** C, **exercise** 1; (b) computer mouse movements of child C, exercise 3.

listen to short segments of the song "Flute and Drum" by clicking on the graphic representations and then to match headings describing what was heard with the appropriate graphic representation. Data recorded indicated that child C first listened to each of the melodic segments and then matched each one with a descriptive heading (Figure 8(b)). Thus, by exercising self-regulation, child C was able to develop a strategy (listening before doing), which enabled him to succeed. Once again, during informal interviews conducted at the end of the program, students mentioned that working on the TLE exercises helped them realize that "if I try I can succeed," and made them "feel calm."

Such positive feelings result from a growing sense of control, which contribute toward an enhanced emotional intelligence (Goleman, 1996).

Discussion and conclusions

Sensitive to the preferences of today's learners as well as the affordances of new media, the In Harmony program proposed a multi-layered model for children to study music using computer technology. Through carefully designed individual study sessions, followed by group tasks and discussions, the participants engaged in a learning process that helped them better understand what they know, how they learn, and how they can improve their musical understanding. Thus, the qualitative data presented above exemplified the students' growing awareness of the role of melodic contour, repetition, and contrast in attaining musical coherency, and the students' ability to apply newly acquired skills within free composition tasks. Moreover, the MLE pedagogical approach nurtured the music classroom as a venue where children may improve their learning skills. Encouraging active group discussions, and providing multiple opportunities for mental expansion, the teachers/mediators helped their students develop creative mental habits relevant to both music and general contexts. The cumulative evaluation results gathered during the program indicated that the In Harmony model and the educational software used successfully scaffolded instruction in music, with beneficial outcomes in musical understanding and general learning skills.

The quantitative positive results obtained from Rey's Complex Figure assessment administered to both the Israeli and the American research groups suggest that the In Harmony program provided a forum in which children, irrespective of cultural and socio-economic backgrounds, may develop working memory skills. While studies have reported correlations between musical experiences and improved verbal auditory memory (Ho, Cheung & Chan, 2003), our data suggests that mental representations that illuminate higher selective classification within a musical context may interact positively with visual memory skills, as indicated by the graphic representations of the children's musical understanding discussed above.

Recognizing the pilot proportions of the current study, future research is needed that will include a larger sample of participants, comprising children of different ages, socio-economic backgrounds, and cultures. Increasing the number of participants will enable us to address more directly the combined and individual impact of multiple representations, reflective logs, and group discussions on the enhancement of the targeted learning skills. Collaborative international research would provide a broader perspective of the impact of cultural differences on the learning processes addressed in the In Harmony program. Most importantly, continued research would assess the long-term effect of the benefits of the In Harmony model for music education and for improved learning skills. Finally, future development would allow researchers to design additional exercises for the TLE software program, introduce tunes from different cultures into the Impromptu library, and upgrade the technical efficiency and general appearance of the of TLE and Impromptu software programs.

In conclusion, the In Harmony model sought to create a holistic environment sensitive to the preferences of today's students and to their individual modes of learning. By proposing a technology-based music education curriculum, it provides a model of how music education classrooms may stimulate active learning. Moreover, the TLE and Impromptu software provided a challenging context in which to develop musical understanding and select learning skills, e.g. working memory, self-regulation, and cognitive flexibility. Based on awareness that consistent use of these skills facilitates children to become better learners (Feuerstein et al., 1988, 2006, 2010; Klein, 1996; Tzuriel 2001), the In Harmony model helped us attain a better understanding of mechanisms linking music education and enhanced scholastic achievement.

Funding

This research was funded by the Jaffa Institute, Jaffa, Israel.

Notes

1. See http://www.tuneblocks.com/whoarewe.jsp
2. See www.icelp.info

References

Bamberger, J. (1991). *The mind behind the musical ear*. Cambridge, MA: Harvard University Press.

Bamberger, J. (2000). *Developing musical intuitions: A project-based introduction to making and understanding music*. New York, NY: Oxford University Press.

Berchin, J. (1991). Spontaneous comparative behavior and categorization: The links between mediated instruction and reading comprehension. In D. S. Martin (Ed.), *Advances in cognition, education and deafness*. Washington, DC: Gallaudet University Press.

Brand, E. (1997). Children's in-action mental model of their own learning as inferred from their behaviors when learning a song. Unpublished doctoral dissertation, School of Education, Tel Aviv University.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9–13.

Cohen, V. (1997). Explorations of kinesthetic analogues for musical schemas. *Bulletin of the Council for Research in Music Education*, *131*, 1–13.

Davidson, M. C., Amiso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulation of memory, regulation and task switching. *Neuropsychologia*, *44*, 2037–2078.

Diamond, A. (2006). The early development of executive functions. In E. Bialystok, & F. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). New York, NY: Oxford University Press.

Diamond, A. (2007). *Supporting online material for preschool program improves cognitive control*. Science 317, 1387 (2007) DOI: 10.1126/science.1151148 Retrievd from http://www.sciencemag.org/content/318/5855/1387/suppl/DC1

Downton, M. P., Peppler, K. A., Portowitz, A., Bamberger, J., & Lindsay, E. (2012). Composing pieces for peace: Using Impromptu to build cross-cultural awareness. *Visions of Research in Music Education*, *20*, 1–37. Retrieved from http://www-usr.rider.edu/~vrme/v20n1/index.htm

Feuerstein, R., Feuerstein, R., & Falik, L. (2010). *Beyond smarter: Mediated learning and the brain's capacity for change*. New York, NY: Teachers College Press, Columbia University.

Feuerstein, R., Feuerstein, R. S., Falik, L. H., & Rand, Y. (2002). *The dynamic assessment of cognitive modifiability*. Jerusalem, Israel: ICELP Press.

Feuerstein, R., Feuerstein, R. S., Falik, L., & Rand, Y. (2006). *Creating and enhancing cognitive flexibility: The Feuerstein Instrumental Enrichment Program*. Jerusalem, Israel: ICELP Press.

Feuerstein, R., Feuerstein, R. S., & Feuerstein, A. (2003). *Learning potential assessment device – Basic: Manual*. Jerusalem: ICELP Press.

Feuerstein, R., Klein, P. S., & Tannenbaum, A. J. (Eds.) (1999). *Mediated learning experience (MLE): Theoretical, psychosocial and learning implications*. London, UK: Freund Publishing House Ltd.

Feuerstein, R., Rand, Y., & Rynders, J. E. (1988). *Don't accept me as I am* (2nd ed.). New York, NY: Plenum Press.

Goleman, D. (1996). *Emotional intelligence: Why it can matter more than IQ*. New York, NY: Bantam Books.

Gooden, A. R. (1996). *Computers in the classroom: How teachers and students are using technology to transform learning*. Indianapolis, IN: Jossey-Bass and Apple Press.

Gruhn, W., & Rauscher, F. (2002). The neurobiology of music cognition and learning. In R. Colwell, & C. Richardson (Eds.), *The new handbook of research on music teaching and learning* (pp. 445–460). Oxford, UK: Oxford University Press.

Hallam, S. (2010). The power of music: Its impact on the intellectual, social and personal development of children and young people. *International Journal of Music Education: Research*, *28*, 269–289.

Ho, Y. C., Cheung, M. C., & Chan, A. S. (2003). Music training improves verbal but not visual memory: Cross-sectional and longitudinal explorations in children. *Neuropsychology*, *17*, 439–450.

Klein, P. S. (1996). *Early intervention: Cross-cultural experiences with a mediational approach*. New York, NY: Garland.

Kreiger, S., & Kaplan, M. (1990). Improving inattention and reading in inattentive children through MLE: A pilot study. *International Journal of Cognitive Education and Mediated Learning*, *1*(3), 185–192.

Meyers, J. E., & Meyers, K. R. (1995). *Rey complex figure test and recognition trial*. Odessa, FL: Psychological Assessment Resources.

Nir-Gal, O., & Klein, S. P. (2004). Computers for cognitive development in early childhood: The teacher's role in the computer learning environment. *Information Technology in Childhood Education Annual*, *1*, 97–120.

Portowitz, A., & Klein, P. (2007). MISC music: A music program to enhance cognitive processing among children with learning difficulties. *International Journal of Music Education*, *25*, 259–271.

Portowitz, A., Lichtenstein, O., Egorov, L., & Brand, E. (2009). Underlying mechanisms linking music education and cognitive flexibility. *Research Studies in Music Education*, *31*(2), 107–128.

Savage, J. (2007). Reconstructing music education through ICT. *Research in Education*, *78*(1), 65–77.

Tzuriel, D. (2001). Dynamic Assessment of Young Children. New York City: Springer.

Webster, P. R. (2007). Computer-based technology and music teaching and learning: 2000–2005. In L. Bresler (Ed.), *International handbook of research in arts education* (pp. 1311–1328). New York, NY: Springer.

Author biographies

Adena Portowitz, musicologist and music educator, received her PhD in musicology from the Bar-Ilan University, Ramat-Gan, Israel. Her main research interests focus on explaining the underlying mechanisms linking music education and enhanced learning skills among at-risk children, and the study of music history within a cultural context. She lectures in the Department for Comparative Literature, BIU, serves as a researcher in the School of Education, BIU, and is a founding member of the music education program at the Givat Washington Academic College. She is also editor of the international, peer-reviewed journal, *Min-Ad: Israel Studies in Musicology Online*, sponsored by the Israel Musicological Society.

Kylie Peppler is an assistant professor of learning sciences in the School of Education at Indiana University Bloomington. An artist by training, she engages in research that focuses on the intersection of arts, new media, computation, and informal learning. She is coeditor of *The Computer Clubhouse: Constructionism and Creativity in Youth Communities* (Teachers College Press, 2009) and *Textile Messages: Dispatches from the World of E-Textiles and Education* (Peter Lang Publishing, 2013). Peppler received a PhD in education from the University of California, Los Angeles. Contact her at kpeppler@indiana.edu.

Michael Downton is an assistant professor in the Department of Curriculum and Instruction at St. John's University. He is interested in the role intuition, practitioner involvement, and student discourse plays in learning, as well as the integration of the arts and music in the design of constructionist learning environments.