Journal of Mathematics Education
December 2016, Vol. 9, No. 2, pp. 97-108

Students Learning about Music-Math Connections by Playing with Cuisenaire Rods

Claudia Saldaña
Olga Kosheleva
The University of Texas at El Paso, U.S.A.

The aim of this pilot study is to show how students from Music and Arts-Based Program (MABP) inspired by El Sistema, Venezuela, discovered music-math connections in their play with Cuisenaire rods and Xylophone resonator pipes. It was part of the bigger qualitative, ethnographic study to explore how art and music can be used as a mediating tool for children to construct meanings and to develop cognitive learning and social skills. We endeavored to enhance complementary learning environment opportunities provided by the program. In this paper we first describe main characteristics of El Sistema. Then, we describe our program and the observation pilot study that was conducted at an Elementary school in the Southwest of United States with ELL Latino students from an immigrant community. We show the diverse representations and meanings gathered from observations of children's play where connections of math and music were established. One of the main goals of our program is to prepare future entertainers. The students described in our observations are future professional entertainers who already participated in music performances for the public.

Key Words: Music education, el sistema, manipulatives, play.

"Art naturally links to mathematics in a variety of ways, including identifying patterns, building sense making, grasping a context, solving problems, using prior knowledge to inform how to approach novel problems, using symbols and shapes to communicate ideas, creating visual models and illustrations to support thinking, using tools to think about concepts, and a focus on hands on learning experiences" (Bush, Karp and Nadler, 2015).

We conducted the observation pilot study in an Elementary school in the Southwest of United States with English Language Learners Latino students from an immigrant community (25 girls and 9 boys, grades 2nd to 5th). These students participated in Music and Arts-Based Program (MABP) inspired by El Sistema. In the original implementation of El Sistema there are only music and art activities. In our after school El Sistema inspired program we incorporated hands-on mathematical activities that provided meaningful connection of music and mathematics.

El Sistema is the successful music education program from Venezuela (El Sistema Global, 2015). El Sistema transforms children's lives along the diverse parts around the world, operating with a same purpose: children, music, socialization and impoverished communities. El Sistema-like programs emerged in different parts of the USA and the world (El Sistema Global, 2015).

"Many individuals felt that ensemble music could uniquely promote high learning demands for children in under-resourced communities unlikely to provide such learning for local children during after-school program" (Brice Heath, 2015, p.188). These types of programs provide "complementary learning environments for those living in underresourced circumstances in modern economics" (Brice Heath, 2015, p.181).

The activity system diagram (Costa & Mota, 2014) showed the features and characteristics that make El Sistema as an Activity System. The authors explained that music is the principal artifact mediating the connection between children, community, orchestra, and music education, (Fig 1).

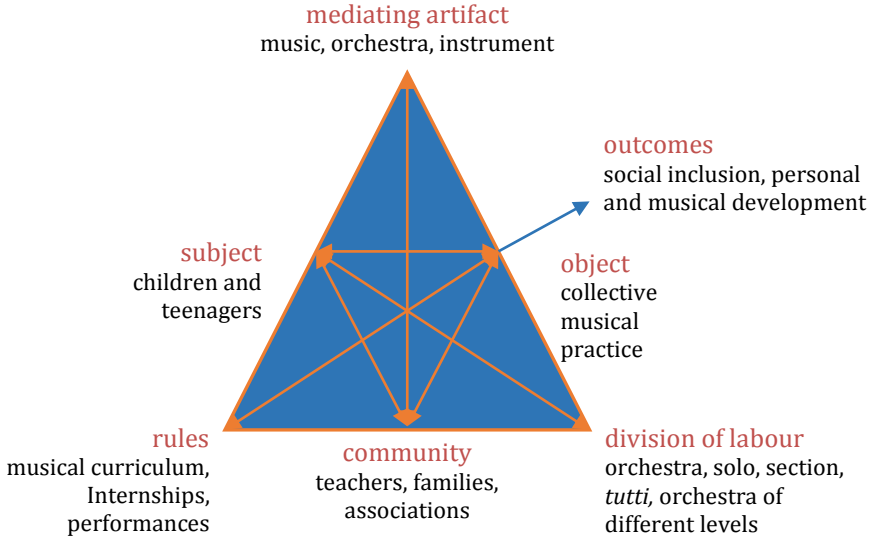

Figure 1. *Activity system in Orquestra Geração. (Castro & Mota, 2014, p.72) (adapted from Engeström, 2001; Welch, 2007).*

Our Program

The MABP includes music teachers, music orchestra performers, and volunteers. Volunteers came from symphony orchestra, music department and college of education from local university. Music teachers teach music theory and piano lessons, orchestra performers teach collective music performance, and volunteers support music program.

The program takes place Monday through Thursday, 3:15 - 5:30 p.m. in three stages: academic support (for homework or recreational games); outside-play; and music class instruction (theory lessons, violin/cello practice, etc.).

During two field trips students went to art museum exhibits and concerts and performed for the community. They observed paintings, sculptures and connected their experiences with music (Figure 2).

Figure 2. *Museum visit.*

Children showed motivation to actively participate in these art workshops. They learned new vocabulary through art instruction, acquired enhanced confidence to articulate their ideas and to ask questions.

Observations of Students' Play

This pilot study was a part of the bigger qualitative, ethnographic study driven by the research design that will provide the means to understand how art and music can be used as a mediating tool for children to construct meanings and to develop cognitive learning and social skills. Our goal was to enhance complementary learning environment to allow students involved connect music explorations with mathematics.

The theoretical framework that supports the data collection in order to understand participants meanings and experiences through the research analysis can be divided into four perspectives: Eisner's (2003) provides a framework through art and education, Vygotsky's (1971) Zone of the Proximal Development (ZPD), the sociocultural perspective that is developed through the lens of Activity theory (Engeström, 2001; Welch, 2007), and Lave and Wegner's (1991) situated Learning and Apprenticeship theoretical perspective. According to Brice Heath (2015) students living in impoverished communities often have essential curiosity and desire to know/learn more.

> Young children growing up in families and communities that have neither time nor financial resources to access or create playful, imaginative, language rich exploration opportunities often enter school without feeling they "own" fundamental ways of learning. It is this

> sensation that feeds children's curiosity, eagerness to explore, and willingness to imagine beyond what is given. (p.180)

Our initial observations made by group of doctoral student and professor from local university confirmed children's curiosity. The IRB proposal was approved in spring 2016, and the appropriate assent and consent forms were signed. Initial observations showed a lot of students' curiosity, therefore team of observers decided to bring mathematical manipulatives, Cuisenaire rods (colored wooden rods) (EAI Education, 2016), and Xylophone (Xylophone resonator pipe, 2016) to enhance academic support activities. The data was collected during the daily academic support. We observed variety of children's designs and constructions.

As described by Hirsch (1994) children's play with blocks leads to different types of constructions in the following styles: repetition, bridging, enclosures, patterned arrangement, and representation (pp. 9-25).

Below we present examples from each style:

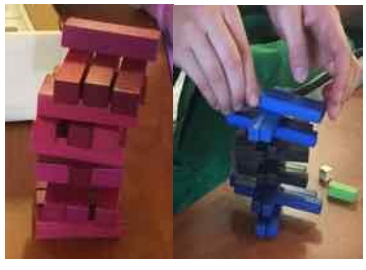

Figure 3. *Repetition style.*

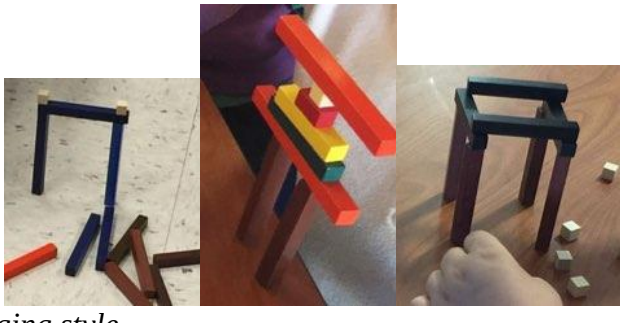

Figure 4. *Bridging style.*

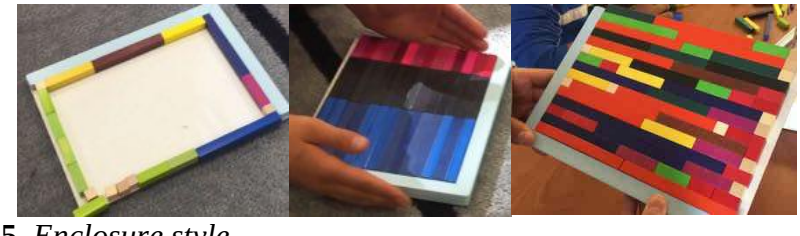

Figure 5. *Enclosure style.*

Figure 6. *Patterned arrangement style.*

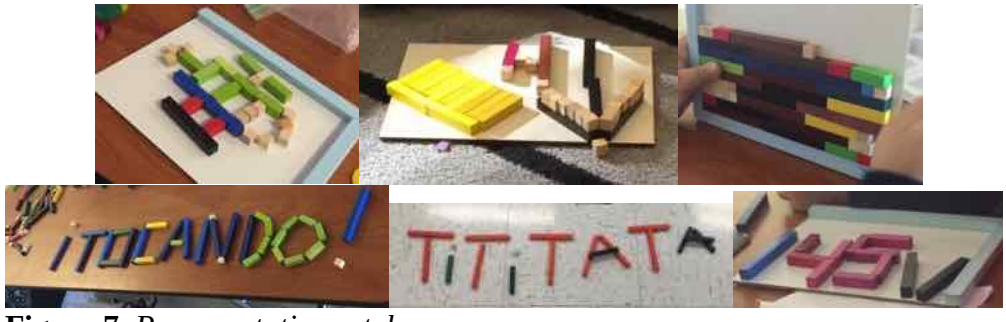

Figure 7. *Representations style.*

Case 1. Students explored the objects before play, asking about, observing, creating and imitating other students' representations. The students asked, "what is this? What can I do with it?" Schaefer (1993) explains that during play children try to answer these types of questions (p.1).

Cynthia and Carlos were piling up the rods following a repetition-tower style, (Figure 3). Mario created a bridge representation style, (Figure 4), right. Carolina worked quietly and was very engaged doing the activity of tiling the rods together using enclosure style, (Figure 5), center. Andrea created grass and fence representation, (Figure 6), left. Marco created a robot representation style, (Figure 7). Hirsh (1994) stated that, "When children are once able to see blocks as building material that is capable of being put together in an ordered arrangement, a variety of methods, patterns, and techniques seem to suggest themselves to them" (p.18).

Case 2. Students from second grade started creating sun, persons, and house. Sandy represented a family. She asked: "Que es lo que brilla?" (What is it that shines?). Later, when showing her representation, she said "son personas, un sol y una flecha" (they are persons, sun and arrow) (04/14/16), (Figure 8).

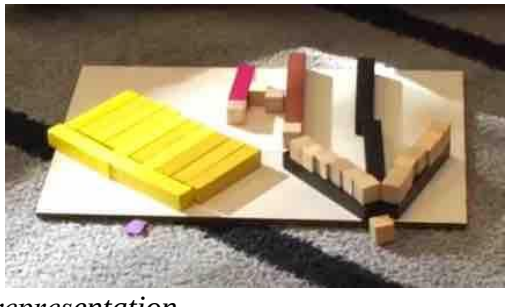

Figure 8. *Sandy's representation.*

Emma followed specific pattern, (Figure 9). Karla was impressed with her construction and said "Ms. mire lo que hizo Emma" (Ms. Look what Emma did) (04/14/16). Drew, Christie, Johnson, Meckley and Nell (2008) recognized that learning process occurs during socialization and playing with others, "children build knowledge through active questioning and information gathering combined with hands-on experiences and direct personal-social interactions" (p.40).

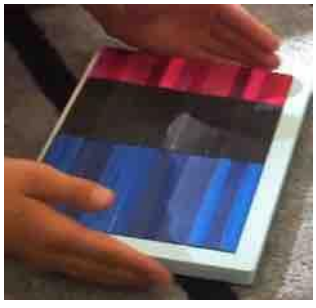

Figure 9. *Emma's enclosure.*

Case 3. Vygotsky (1978) explains that play is something where children used their imagination, however, this imaginary situation is created in the reality, "an imaginary situation that initially is so very close to the real one" (p.103). Mario created his representation imitating other students' work. He called it "Muralla China" (Wall of China) (05/23/16), (Figure 10). Mario connected ideas with his learning experiences, re-creating his knowledge through play.

Figure 10. *Muralla China.*

"Naming becomes very usual among older children. The name is often announced as an advanced plan" (Hirsch, 1994, p.21). Carlos played with words creating a visual representation of the name used in their music program. He emphasized words using exclamation signs, and he wrote words in his native Spanish language. Another student used rods to create numbers, (Figure 11). The observers think that children were expressing what was on their minds (e.g., participation in music program, doing math homework using numbers). By inserting exclamation signs Carlos was expressing his

excitement about music program. We believe he was very proud and actively involved in the activities this program offered.

Figure 11. *Words and numbers.*

Also, students created representation of musical rhythms, creating a connection with their music lessons, (Figure 12).

Figure 12. *Musical rhythm syllables.*

Connecting Cuisenaire Rods and Xylophone Resonator Pipes

The students were given Cuisenaire rods (Learning with Cuisenaire Rods, 1991) to play and explore. As the booklet states "Give students time to play with the rods before using them in directed lessons. Students are likely to make designs, create pictures, and build three-dimensionally. They will begin to notice rod attributes and relationships…" (p.1).

Figure 13. *Example of trial and error approaches.*

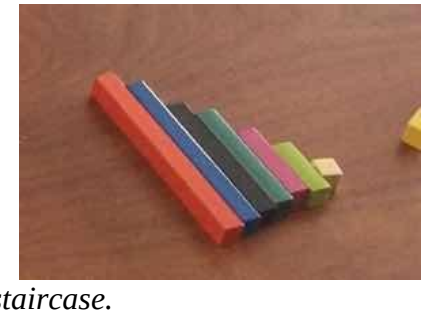

Figure 14. *Incorrect staircase.*

We observed that children started arranging rods in order to make a staircase using trial and error approach, (Figure 13). In the left Figure a child is attempting to fit the yellow rod in the place where it doesn't belong. In the right Figure similar thing is happening with brown rod. As presented in (Carpenter, 1989) when students are involved in problem solving they are motivated to refine and build on their own processes, try and discard some ideas, and move to another possibilities. This is exactly what we observed in students' trial and error approaches.

More examples are shown in (Figure 14). There should be ten rods in the correct staircase (when using all provided lengths and colors), however only seven rods are used (yellow, brown, red rods are missing) and yellow and brown rods are missing.


Figure 15. *Correct staircase.*

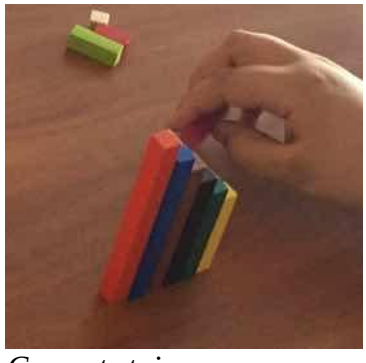


Figure 16. *Correct staircase.*

In (Figure. 15 and 16) correct staircases built horizontally and vertically are shown. We expected students to construct horizontal staircase, the vertical construction came as a surprise to observers because typically in the literature examples of students work with Cuisenaire rods are shown in horizontal placement (Learning with Cuisenaire Rods, 1991).

We observed children's approaches to placing the pipes on the base. Initially they placed the pipes in incorrect, reversed (mirror) order. Then Mario noticed that the pipes were not following the correct order. He pointed

out to the pipes and said, "no, este va aquí" (no, this goes here) (05/24/16), (Figure 17), left. Then Sandy placed them in the correct order and children checked it again, (Figure 17), right.

Figure 17. *Mario and Sandy placing the pipes.*

In a similar way, Daniel started a new play with Xylophone.

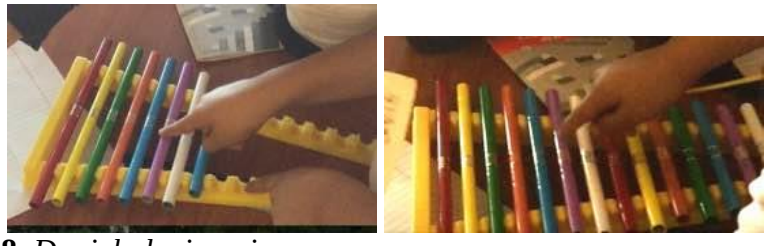

Figure 18. *Daniel placing pipes.*

He placed some of the pipes in the correct order and asks his peers: "¿Quien pone los chiquitos? Ya puse los grandes" (who can place the small ones? I placed the large ones) (05/24/16). He continued placing smaller pipes, using trial and error, and finally was able to place them correctly, (Figure 18). He was very proud and expressed his satisfaction by saying in English, "Ms. I could it by my own, everything" and then repeating in Spanish, "Yo los hize todos, yo solo" (I made it by myself) (05/24/16). He used English and Spanish language to express his feelings during play.

Vygotsky (1978) recognized that play implies rules and children are following rules when playing. "The role that child fulfills, and her relation to the object, will always stem from the rules" (p.95). We saw that Daniel was very proud of his achievement of placing the pipes in correct order.

"Young children engage in music as an exploratory activity, one that is interactive, social, creative, and joyful" (Kemple, Batey, and Hartle 2004, p.31). The explorations with Xylophone were multifaceted. The children explored playing together collaboratively. Music teacher guided them during Xylophone play. She explained children not only how to follow color notes from the musical book, she also explained connection between length of a pipe and the sound.

Students were playing with wooden rods and Xylophone pipes. Students observed similarities between rods and pipes, e.g., how rods and

pipes were represented by different lengths. Children were encouraged to initiate the process of comparing lengths of rods, and lengths of pipes. As a result, after several trial and error attempts, they positioned rods and pipes in descending order. The established common pattern through connection between Cuisenaire rods and Xylophone pipes worked like magic. When the Xylophone pipes were placed in correct order the music came to life. Students used their prior knowledge and music skills to play several songs, e.g., "Twinkle, Twinkle, Little Star" (Taylor, 1806). They were very excited to see this music connection.

Conclusions

We closely observed the positive effects that children had during play activities; "such feeling of enjoyment are evident in the smiles, laughter and joy exhibited by children during and just following the play" (Schaefer, 1993, p.1). Researchers describe essential characteristics of children's play (Almy, 1984; Rubin, Fein, and Vandenberg, 1983): intrinsic motivation – children worked in a free and open environment; attention to process rather than product - no established goal, trial and error; nonliteral behavior or make-believe - children used imagination, told stories; freedom from external rules - the rules of play are regulated by children; freedom of exploration of new items or environments - children explored new objects; active engagement.

As we mentioned before, according to Brice Heath (2015) students living in impoverished communities often have essential curiosity and desire to know/learn more. This essential curiosity was one of the emerging themes we observed and it was the basis for our experiment of bringing mathematical manipulatives in MABP after school program. The connection and common patterns students discovered by playing with Cuisenaire rods and Xylophone pipes provided them with enhanced learning and emotional expression. The main focus of the program is music education, and this activity enabled students to make meaning in the process of comparing lengths of rods, and lengths of pipes using prior music knowledge.

We posit that this experiment was successful and it provided continuity to the interrelation between art and mathematics outside the classroom. Our recommendation is that it will be beneficial to any after school program to incorporate interdisciplinary activities, because it is important to achieve holistic learning for children.

The described program activities are contributing to using music educational strengths in the field of entertainment education. Shingal and Rogers (2012) in entertainment-education book states that "Music is one of the oldest entertainment traditions… However, its educational potential remains largely untapped and underutilized" (p.119).

One of main goals of our program is to prepare future entertainers. Students already performed for public and, as program progresses, many students will learn to become professional entertainers.

References

Almy, M. (1984). Reaffirmations: Speaking Out for Children. A child's right to play. *Childhood Education*, 60(5), p.350.

Brice-Heath, S. (2015). Museums, Theaters, and Youth Orchestras Advancing Creative Arts and Sciences within Underresourced Communities. In W.G. Tierney (Ed.), *Rethinking Education and Poverty* (pp. 177-199). Baltimore, Maryland: Johns Hopkins University Press.

Bush, S., Karp, K., & Nadler, J. (2015). Artist? Mathematician? Developing Both Enhances Learning! *Teaching Children Mathematics*, 22(2), 61-63.

Carpenter, T. P. (1989). Teaching as problem solving. In R.I.Charles and E.A. Silver (Eds), *The Teaching and Assessing of Mathematical Problem Solving*, (pp.187-202). USA: National Council of Teachers of Mathematics.

Costa, J. A., Cruz, A. I., & Mota, G. (2014). The Orquestra Geração-Unveiling its Complexity. *ISME Commission on Research*, 59.

Drew, W., Christie, J., Johnson, James., Meckley, A., & Nell, M.(2008). Constructive Play: A Value-Added Strategy for Meeting Early Learning Standards. *YC Young Children*. 63 (4), 38-44.

EAI Education (as of 2016). Available at http://www.eaieducation.com/. Accessed on May 2016.

Eisner, E. (2003). Artistry in education. *Scandinavian Journal of Education Research*, 47 (3), 373-384.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), 133–156.

Sistema Global. (2015). Retrieved from http://sistemaglobal.org/el-sistema-global-program-directory/

Hirsch, E. (1994). *The Block Book*. Washington, D.C: National Association for the Education of Young Children.

Kemple, K., Batey, J., & Hartle, L. (2004). Music Play: Creating Centers for Musical Play and Exploration. *YC Young Children*, 59 (4), 30-37.

Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. New York: Cambridge University Press.

Learning with Cuisenaire Rods [Brochure]. (1991) New Rochelle, NY.

Rubin, K. H., Fein, G. G., & Vandenberg, B. (1983). Play. In P.H. Mussen (Ed.), *Handbook of child psychology: Formerly Carmichael's Manual of Child Psychology* (pp.693-774). New York, NY: John Wiley & Sons.

Schaefer, C.E. (1993). *The therapeutic powers of play*. Northvale, N.J: Aronson.

Singhal, A., & Rogers, E. M. (2012). *Entertainment-education: A Communication Strategy for Social Change*. Mahwah, N.J.: Routledge.

Taylor, J. (1806). Twinkle, Twinkle, Little Star. English-Poem Song.

Vygotsky, L.S. (1978). *Mind in society: the development of higher psychological processes*. Cambridge: Harvard University Press.

Vygotsky, L.S. (1971). *The psychology of art.* Cambridge, Mass., M.I.T. Press.

Welch, G. (2007). Addressing the multifaceted nature of music education: An activity theory research perspective. *Research Studies in Music Education*, 28(1), 23–37.

Xylophone resonator pipe (as of 2016). Available at http://www.terapeak.com/worth/xylophone-wonderful-merveilleux-15-tunes-note-aluminum-resonator-pipe-wood-base/191796074687/. Accessed on May 2016.

Authors:

Claudia Saldaña
The University of Texas at El Paso, U.S.A.
Email: csaldanacorral@miners.utep.edu

Olga Kosheleva
The University of Texas at El Paso, U.S.A.
Email: olgak@utep.edu