

Full Length Research Paper

# Bharatanatyam and Mathematics: Teaching Geometry Through Dance

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Received 18 August, 2015; Accepted 18 September, 2015

**Bharatanatyam is a highly codified and schematized Asian Indian style of classical dance that accommodates the different kinds of learners. This dance is culturally relevant to Asian Indian American students, but the findings are applicable to students from other demographics that are interested in learning math through dance. Many Asian Indian students learn *Bharatanatyam* for cultural maintenance and preservation. Dance is also a beneficial medium to teach basic geometric shapes to young children because dance is an engaging art curriculum that can be used in schools. This mixed methods study informed by categorical content analysis is designed to recommend a framework for exploring how Asian Indian students can learn basic geometric shapes through *Bharatanatyam*. The study investigates dance movements called *adavus*, cultural relevance, and integration of elements from dance and geometry and the implementation of alternate strategies such as dance instruction to teach and learn basic geometric shapes. The data analysis revealed the benefits of dance and math integration.**

**Key words:** Asian Indian students, Bharatanatyam, geometry, learning styles, teaching and learning.

## INTRODUCTION

For centuries dance has been regarded as an aesthetic experience, an entertaining work of art, and a vehicle for gratification. History also demonstrates that dance (synchronized kinesthetic art) has been utilized in other areas such as psychology, counseling, and medicine (Chodorow, 2013; Bracilovic, 2009; Meekums, 2015). For example, dance has been used in treating depression, teaching languages and mathematics. Lazonov (1981)'s experimentation with ballet dancers and opera singers to teach young children how to read is a classic example of practical use of dance. His 'suggestopedia' made learning

a pleasurable, natural process (Hansen, 2005). This clearly demonstrates that dance has utilitarian purpose because, in addition to its aesthetic appeal, it has established therapeutic, cognitive and instructional benefits. It is established that "Incorporating music, art, role-playing and games into the curriculum" made the lessons engaging to learners (Cook, et al, 2013; Dale, 1946, 1996; Prichard and Taylor, 1981, 22). The systematic body movement through dancing is used to support learning. In this paper, I explore the integration of dance and the teaching of mathematics, specifically basic

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geometric shapes using the Asian Indian dance called *Bharatanatyam*.

## Background

*Bharatnatyam* is orchestrated body movements that are synchronized to Carnatic music. Unlike other western dance styles, *Bharatnatyam* dances are performed to describe the stories sung using vocal and instrumental music. The Asian Indian dance called *Bharatanatyam* is more than coordinated and stylized movements. It is a semiotic medium, which incorporates schematized body movement, music, and paralinguistic features to tell stories from the Hindu epics (e.g., *Ramayana* and *Mahabharata*). This highly codified style of dance originated in the state of Tamil Nadu in South India in the 4<sup>th</sup> century (Banerjee 2013; Sangeetha and Ragothaman, 2014). The term, *Bharatanatyam* is a compound word from the Sanskrit language meaning: *bha* /expression+ *ra*/music+ *tha*/rhythm+ and *natya*/dance). It was sage Bharata *muni* that created this transmediated practice of storytelling. Later, in the 20<sup>th</sup> century, Rukmini Devi Arundal introduced *Bharatnatyam* to the west (Samson, 2010).

In *Bharatanatyam*, there is a tacit element of instruction - the dancer/teacher guides the audiences through codified bodily movements and schematized expression (Ramanath, 2009). One example is the *Jathi* interpreted by Savitha Shastry, dance master of the *Kalakshetra* school of *Bharatnatyam* (see video link <http://safeshare.tv/w/iegEtLKOnM>) (see appendix A for permission from the author). Here, the dancer creates rigorous geometric movements that correspond to the shapes taught in mathematics class. The following section discusses the video and mathematics instruction including how dance can be used to teach math.

## Video

This dance is called *Jathi*, which is a series of steps (referred to as *adavus* in *Bharatanatyam*) strung together in a meaningful way.

## Geometric shapes

The various geometrical shapes that are formed with the first line comprising "*Tha Dhi Thaka Thakadi Thajum*" are - triangle, right angle, line segment, diagonal, half circle, circle, diamond, and obtuse and acute angles. Similar and many other figures emerge as the dance progresses. The visual, spatial, and aesthetic elements are visible in this *Jathi*. *Bharatnatyam* enables the learner to use the aesthetic elements while learning the basic geometric shapes (see appendix D for shapes). Dietiker and

Brakoniecki (2014) point out that aesthetic dimension of mathematics learning experiences is not addressed in schools and it needs attention.

During the author's observations of young adults learning *Bharatanatyam*, she realized that dance could be used to teach children valuable skills including basic geometric shapes such as line, square, rectangle, and triangle. Geometry is taught using textbooks and worksheets at school to help students master the concepts precisely. These linguistic materials help children learn and practice math concepts. However, the visual and kinesthetic learners in our classrooms may depend on other modalities to learn math and according to Dietiker and Brakoniecki (2014, 33) "...There are many questions that remain unanswered about how diagrams are used by texts, teachers, and students. Possibly, some of the potential confusion of reading diagrams...may be overcome by explicitly supporting the different ways students read geometrically". Hence, dance may be an engaging and appropriate medium, to help students, especially students who are visual and kinesthetic learners, learn basic geometric shapes.

*Bharatnatyam* is also an expressive dance form that uses semiotics, storytelling, music, culture, religion, mathematics, philosophy, and history and this dance is used to help children of Asian Indian origin to become culturally grounded. Apart from learning to express through dance, children also learn the various concepts that are required to understand mathematics through dance (Jiesamfoek 2012; Klingenberg, 2012; McCarthy-Brown 2014). Further, Rodenfeld (2013, 213) recognizes the skill set needed in both of these disciplines of math and dance, "choreograph, decide, collaborate, experiment, tinker, revise, play, apply, represent, analyze, discover. Most of these words can be used to describe mathematical problem solving as well as a choreographic process." Subsequently, integration of math and dance may be cognitively beneficial to children who are familiar with math and dance concepts because "cognition is the emergent outcome of dynamic and adaptive sensorimotor interactions with the social and physical environment" (Semin and Smith, 2013, 125). Before analyzing the effects of integrating math and dance, we should examine how math is taught in schools.

## Mathematics instruction in school

Several researchers note how traditionally mathematics has been taught predominantly using the lecture method. This approach is teacher-centered with a passive, sedentary learner who works in isolation to solve problems through rote memorization (Dunn and Dunn, 2012; Galeet, 2012; Westreich, 2012; Yang and Dai 2011). Such traditional methods privilege only one channel or mode of understanding - the linguistic. These methods do not accommodate the variety of learners in

classrooms today. It is not my intention to disparage rote-memorization because dance media (e.g., *Bharatanatyam*) is also learned through memorization; however, dance uses different modalities to teach various concepts to learners.

Among students there is a feeling that math is a hard subject. Teachers often report that children either get it or do not (Cornell, 1999; Duru, 2010). Further, Dietiker and Brakoniecki (2014, 6) clarify "it is not surprising that learning mathematics appears to many students as a game where the rules seem arbitrary and hidden." Traditional methods disengage students who learn differently using alternate methods of learning (Ultanir, 2012, 198). Therefore, teachers must look for innovative teaching strategies to help struggling students in their math classes. Further, alternate teaching methods may produce higher engagement in students (Werner, 1978; Zakaria, 2013). Westreich (2002) recommends dance to teach math because dance is an engaging modality and it may help students visualize a problem. In addition, dance may be an appealing vehicle to help visual and kinesthetic learners to understand the basic geometric shapes such as square, rectangle, triangle, and diamond.

Dietiker (2014, 1) argues, "Students are expected to develop sophisticated ways to interpret diagrams using context and convention." For some students, such deduction of figures may be difficult or impossible unless an alternate method of teaching is employed. Teachers have recognized the benefits of teaching math using interactive and engaging methods (Dale, 1946, 1996; Klingenberg, 2012; and Redmond, 2011). For example, "SHINE's curriculum uses kinesthetic learning to help our students better understand and retain material. More importantly, it helps excite our students about math, and changes their attitudes about their own potential" (Shine for Girls, 2014, 1). SHINE for Girls is a program designed by Shah, a Massachusetts Institute of Technology researcher to help girls to excel in STEM fields. The founder and director of SHINE is a dance professional, who combines math and dance to teach girls about math concepts. Therefore, *Bharatanatyam* may be an engaging alternate method for students who have the prior knowledge and experience of this dance to learn the basic geometric shapes.

## LITERATURE REVIEW

There is copious research on the topic of integration of mathematics and dance (Werner, 1978; Brillon, 2014; and Rosenfeld, 2013), but there were no studies that looked at teaching geometry utilizing *Bharatanatyam*. Research has shown that dance can be integrated in teaching math while teachers explore "a meaningful way to encourage [students] to consider alternatives to traditional teaching" (Cook et al., 2013, 598). Also, new

approaches to problems of teaching number theory through embodied movement and dance is sought after (Dale, 1946, 1996; Devichi and Munier, 2013). In addition, Rosenfeld (2013, 211) claims that dance facilitates math learning including concepts such as, "congruence, symmetry, transformation, angles and degrees, attributes, pattern recognition, symbols, and mapping on a coordinate grid."

Zuckerbros (2011) describes a 6<sup>th</sup> grade teacher's approach to guiding her students to choreograph a dance. Through her strategy, the teacher encouraged her students to learn elements of geometry and write the directions to recreate the dance. Rosenfeld (2013), a trained percussive dancer, uses dance to teach her elementary students to learn to create different shapes. She helps her students understand how math is not just figurative depiction, but a thought process. Rosenfeld teaches her students to take responsibility while learning by creating an environment where students can experiment and later discover the shapes by themselves instead of depending on the teacher to dictate to them (Jiesamfoek, 2012; Tomlinson, 2011).

According to McCarthy-Brown (2014, 128), "dance is an expression of culture and through dance, cultural traditions are preserved, lived, shared, and explored." Along with cultural preservation, it is also established that dance can be utilized to teach math; however, there is no specific study on *Bharatanatyam* and math. This mixed methods study examines the students' understanding of learning the basic geometric shapes using *Bharatanatyam*. The study was conducted after procuring the approval from the Institutional Review Board from the University of Texas at San Antonio. All of the participants are recognized with numbers to protect their identities

## Research Question

How can *Bharatanatyam* dance instruction be applied to mathematics teaching, specifically to teach basic geometric shapes?

## Theoretical framework

This study draws from social constructivism (Steedman, 2000; Shoval, 2011; Young and Collin, 2004), theory of multiple intelligences (Gardner, 1988), and semiotics (Sipe, 1998). Social constructivism theorists "believe that much can be learned from investigating an individual's sense-making strategies as he or she attempts to understand mathematical ideas" (Lambdin and Westcott, 2007, 15). The concept of integrating knowledge from one domain into another can be applied to dance learning because like math, dance utilizes the same concepts of sense making and comprehension of ideas (Brillon, 2014;

Steedman, 2000; Westreich 2012). The learner builds knowledge based on her understanding of the world and the interaction with the materials presented.

Semiotics is the study of different sign systems. Semiotics includes semantic (meaning), syntactic (structure), and pragmatic (effect) characteristics (Barthes 1987). The semantic aspect comes from the word(s) and context, while the syntactic is the grammatical structures, and the pragmatic is the effect the signs have on the reader, listener, or watcher. *Bharatanatyam* uses the different sign systems such as music, dance, and expression to convey the same message, which is transmediation of the sign systems (Magee and Leeth, 2014). Transmediation is “the process of translating meaning from one sign system (such as language) to another such as pictures” (Siegel 1995). This method of learning helps students construct knowledge not just by using text or language, but also through painting, dancing, singing, dialoging, and acting (Fauth 1990; Zakaria et al 2013). Transmediation helps promote different ways of knowing and not just the linguistic modes of representation (Siegel, 1995).

Transmediation is the connection between two sign systems that has to be created through critical thinking and it is a multiplicative process (Tembrioti and Tsangardou, 2014). Nodelman observes that words have a greater potential for conveying temporal information, whereas pictures have a greater potential for conveying spatial information (Sipe 1998, 100). Further, transmediation can produce a higher level of learning. Hence, teaching geometric shapes through dance may enable students to grasp the skill set quickly as compared to teaching using the traditional methods of lecturing and through board work (Jensen, 2000).

Multiple intelligences accommodate students with different learning styles in our classrooms. Gardner identifies seven different kinds of learning styles and I am focusing on the four styles applicable for this study. *Bharatanatyam* dancers can be visual, spatial/kinesthetic, auditory, and logical/mathematical. Visual learners expect pictorial aids and other illustrations to help them learn. Spatial/kinesthetic learners understand the lesson if taught using bodily movement and heuristic learning activities. Auditory learners seek out aural instructions and logical/mathematical learners may look for information presented in a calculating and analytical fashion (Gardner 1999). *Bharatanatyam* uses all of these intelligences through movements (exit, entry, poses, and positioning on stage while dancing), music (tonal semiotics), and formations (simulation and coordination including stage movements). According to Poursababian (2012, 25):

...When a struggling student suddenly gets a certain *adavu* or *kannakku* (the math behind a complex set of *adavus*) because of an innovative instructional tweak on my part, the thrill and sense of satisfaction is beyond

words. My *shishyas* [disciples] are like a long-term painting in progress. I create their dance personas one stroke at a time, until they are a visually pleasing canvas of vibrant colors.

## METHODOLOGY

### Participants

The following section is a description of the participants' information. The participants of this study were Asian Indian American students attending schools in three major cities in the southwest region of the United States. The participants were recruited using a flyer at various dance schools in three major cities in the Southwest (see appendix B for the flyer). All of the participants are second generation Asian Indian Americans, who live and go to schools in the US. The study participants ranged from ages four to eighteen.

The study participants were classified as (a) students who have the first hand knowledge of *Bharatanatyam* and *Carnatic* music because either they or their siblings are learning the arts and they attend dance and music recitals and programs with their family periodically, (b) students who have no exposure to dance, and (c) students with cursory knowledge of dance. Some of the participants are attached to music or dance school that teaches using the *guru-shishya* approach of teaching (Banerjee, 2012). This dance requires students to learn from a teacher who is trained in a specific style of Indian music or dance. The schools of *Bharatanatyam* include *Kalkshetra*, *Pandannluru*, *Melattur*, *Tanjavoor*, and *Vazhuvoor* and these styles are region specific to the south Indian states of Karnataka, Andhra Pradesh, and Tamil Nadu. Music schools are either *Hindustani* (North Indian) or *Carnatic* styles (South Indian). The participants in this study were from elementary to university level, who have exposure to dance and music through the dance and music schools and the regional organizations to which they belong.

### Participants' classification

Data was analyzed by classifying *Bharatanatyam* students as follows- (a) students with experience, (b) students with minimal exposure and (c) students without much exposure to *Bharatanatyam*. Table 1 illustrates the classification.

### Date collection

The author provided the study participants with a YouTube video of a *Jathi* performed by Savitha Shastry and asked them to watch and then identify the different geometrical shapes as presented in the dance. Dr. Iyengar emailed the YouTube clip using 'safe share TV' link and gave each one of the students three weeks time to respond to her email request. Due to lack of responses after three weeks of her initial request, the author resent the email and gave them a week's extension for those who had not replied to her first request. After the fourth week, she received detailed descriptions from twenty participants. The data for this study comprised answers to three questions that the students answered (Table 2). The first two questions are brief responses and the third question is a narrative response, where students write about how they can or cannot learn basic geometric shapes using *Bharatanatyam*. Data were collected through written email responses and it was stored in a wiki created for this study.

**Table 1.** Participants' classification.

Participants with dance background	Participants without dance background	Participants with limited dance background
1. Learning the <i>Kalakshetra</i> style of <i>Bharatanatyam</i> for 10 years	4. No experience in dance, but learns <i>Carnatic</i> music.	9. Has experience in dance or music through watching his sister dance and perform regularly. His sibling learns <i>Bharatanatyam</i> (Pandannaluru style).
2. Learned <i>Kalakshetra</i> style for 4 years and quit	5. No experience with dance but learns <i>Carnatic</i> music along with his sibling.	11. Goes to programs regularly to watch dance programs.
3. Completed solo debut twice (in the US and in India). Now teaches while learning the <i>Pandanalluru</i> style.	7. Attends dance and music programs regularly and is interested in watching dance. 8. No experience	12. Loves to dance, but does not know how.
6. Learned the <i>Kalakshetra</i> style for 12 years and performed at her solo debut.	10. Minimum exposure to dance through performances he attends with the family.	17. Watches dance with the sibling.
15. Learning the <i>Kalakshetra</i> style of dance.	13. No experience	18. Loves to go to dance performances, but does not like to dance.
16. Teaches dance at the dance school she graduated from.	14. Minimum experience with Bollywood dances.	19. Parents force him to dance and sing.
20. Is performing the <i>arangetram</i> in 2016.		

**Table 2.** Participants' Questions.

1. What different geometric shapes did you observe/identify in the <i>Jathi</i> ? Name all of them.	2. Do you learn math through dance at school? Write a brief description about learning math using <i>Bharatanatyam</i> after you watched Mrs. Shastri's <i>Jathi</i> .	3. Do you think you can learn basic geometric shapes using dance? Explain why or why not.
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**Research design**

The study utilized categorical content analysis, a type of mixed methods design where the researcher categorizes the text by analyzing units of text (Leiblich et al., 1998). In addition, the parallel form of mixed methods using a conversion design in which qualitative data can be converted into quantitative data was utilized (Mertens, 2010). Categorical analysis is dividing the text into smaller units for analysis. Parallel form is collecting both qualitative and quantitative data simultaneously. The quantitative data was collected and analyzed to draw conclusions from the results (see step 4).

Categorical analysis is conducted using the following steps (Leiblich et al., 1998, 113-114): (1) Selection of the subtext, (2) Definition of the Content Categories, (3) Sorting the Material into Categories, and (4) Drawing Conclusions from the Results.

*The Selection of Subtext* is classifying text as a separate unit depending on the research question. For instance, this study is looking into teaching basic geometric shapes through dance and hence the narrative responses of the participants can be subdivided into shapes recognized and skills learned. All of the other information is ignored in the selected text.

*Definition of the Content* is the different theories or themes that emerge in the text.

The categories are driven by a theory and in this study; the content is defined based on the different learning styles used to understand the basic geometric shapes in the dance *jathi*. For example, this study draws from Gardner's (2009) multiple intelligences theory of learning. The categories are defined using the theory depending on the sub texts chosen for analyses.

*Sorting the Materials into Categories* is analyzing discrete sentences from the data set. This step calls for an external reader's assistance so validity can be established. Leiblich et al. (1998, 113-114) describe that "When two or more judges are involved in sorting contents into categories, this can be done independently, to allow the calculation of the interjudge reliability, or jointly, to create higher sensitivity to the text and its meaning to different readers."

The author consulted a *Pandannaluru* style *Bharatanatyam* dance teacher to cross check the data analysis and offer comments. Except for the skill sets discussed in the paper, she consented to my findings to be accurate. She recommended that the author reword the skills sets identified in the limitations and implications section of the article. The author rephrased the categories later.

Finally, *Drawing Conclusion from the Results* involves statistical

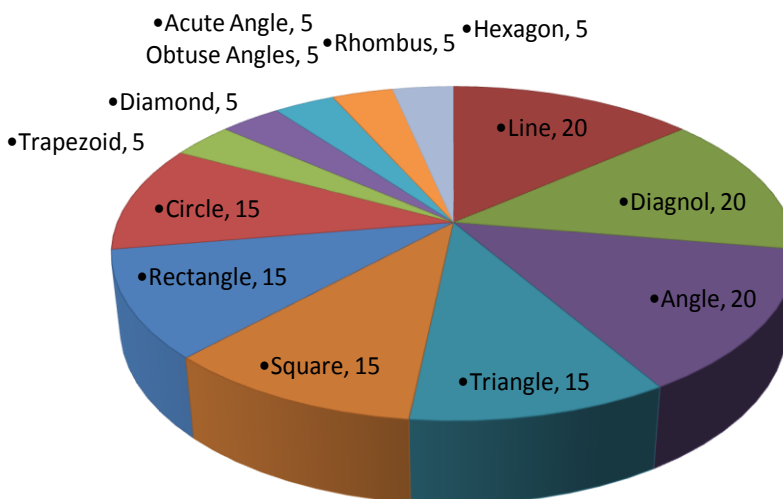


Figure 1. Geometric shapes and frequency in twenty participants.

computations of the sentences and categories. For the purpose of this study, a figure (Figure 1) is included with the number of geometrical shapes the study participants identified through watching the dance and a pie chart with percentages of figures identified by participants. The author will use "...the contents collected in each category ...descriptively to formulate a picture of the content universe in certain groups of people or cultures" (Lebllich et al., 1998, 114).

**Data analysis**

Data was analyzed using categorical content analysis supported by Leiblich et al. (1998). First, subtexts were selected from the participant responses. Then, the sub texts were categorized, and finally, a statistical procedure was applied. These four different steps were applied to all of the texts collected in this study, but the following section lists two examples (data) for each step. The participants are identified with numbers.

**The selection of the subtext**

*No, geometry is much more complicated than what is in a dance and the steps. The steps and shapes made in a dance are simple, only scratching the surface of the complicated math involved in geometry (1)*

I am concerned with the identification of shapes here, so I will select this section of the text for analysis - *The steps and shapes made in the dance are simple (1)*

*I believe that I can use dance to learn Math concepts, specifically geometry, by using dance. The turning of the body with the two hands at a right angle can represent the circumference of a circle while the hand stretch outwardly can represent the radius of a circle. The placement of hands diagonally can represent a cut through a shape. The ending pose can represent the vertices (multiple vertex) of a pentagon (3)*

I will select the subtext that discusses body movements to form a circle - *The turning of the body with the two hands at a right angle can represent the circumference of a circle while the hand stretch*

*outwardly can represent the radius of a circle (3)*

**Definition of the Content:** The text was categorized based on my perceptions of how the participants observed their learning using one or more of the multiple intelligences. The analysis is based on the responses to the questions I posed to the participants.

*The placement of hands diagonally can represent a cut through a shape. The ending pose can represent the vertices (multiple vertex) of a pentagon. When I dance this, it is clear to me (5)*

This dancer is both visual and kinesthetic learner. She needs to picture the shapes formed and she needs to perform the shapes herself through bodily movements to better understand the shapes.

*Yes, I think we can do math using dance because every move they make they could measure it and add it up and get the total. I would prefer to do geometry using dancing because it is fun and I have to search what shapes Ms. Shastry is making while she is dancing (8)*  
 This dancer is kinesthetic, spatial, and logical thinker. He prefers precision through observing the shapes. He also likes to seek out information while watching the visual representation of the shapes.

**Sorting of the materials into categories**

The texts were categorized based on Piaget’s framework of reasoning. The participants ranged from kindergarten (6 years) to college (18 years). The recognition of shapes correlated with their ages. For example, the participants in kinder to second grades were able to identify line, diagonal, and a few angles. Participants from third grades to eight grades identified all of the shapes that the kinder to third grade recognized and triangle, square, rectangle, circle, and parallelogram. The last set of students wrote down all of the previously mentioned shapes and the following shapes – trapezoid, diamond, acute and obtuse angles, rhombus, and hexagon.

Piaget’s frame suggests how children process information and how it is dependent upon one’s age. Piaget’s research also suggests three stages in children’s understanding of materials. The three cognitive developmental stages are – (1) pre-operational, (2)

concrete operational, and (3) formal operational. According to Piaget (as cited in Ultanir, 2012, 46),

*The pre-operational child between the ages of 2 and 7 years uses language and represents objects by images and words. The concrete operational child between the ages of 7 and 11 can classify objects according to several features. The formal operational young adult between the ages of 11 and up becomes concerned with the hypothetical, future, ideological problems. The data collected for this study aligns with Piaget's stages and the following section lists examples from data that conforms to Piaget's framework of reasoning.*

### Pre-operational

*Lines and diagonal...It is fun to learn math using dance that is not done in school (16).*

This writer recognizes the basic shapes and mentions how they do not learn math in a fun way. They prefer learning math-utilizing dance.

*Angles and lines all over...Dance helps me memorize the angles and lines (19)*

This participant also identified the basic shapes and acknowledged that dance aided them in memorization of the shapes. This participant is able to identify one important skill necessary for both dance and math – memorization of concepts.

### Concrete operational

*Circle, trapezoid, triangle, square, rectangle... That would be awesome to learn Math by dance. Math is boring because the teachers write on the board or talk all the time. If dance is used then we have to move and there will be excitement in class. I think, geometric shapes like I saw in this dance can be learn[ed] in an interesting way. It may be difficult for my classmates to understand our Indian dance, so other dance is better (10).*

Here, the student seeks an alternate medium to learn Math. This student seems to suggest that math learning should be done in a fun way and not by using monotonous methods. This writer is able to recognize that there are other ways of learning math. He is also able to articulate the different ways dance engages him. This is a concrete operational concept.

### Formal operational

*Due to the fact that I started learning Bharatanatyam in the fifth grade, I had already learned the basic concepts of math. However, dance helped reinforce many of the concepts I had learned and even strengthened my math skills. Such as the music that goes with the common jathis, learning to count the beats in threes and fours helped with multiplication skills. In regards to geometry, math actually helped me become a better dancer. Bharatanatyam is about having straight lines. So when it came to having a good posture, I would look in a mirror and make my arms 180 degrees or make sure my poses looked straight like the shapes that we learned in school (6).*

This is an advanced concept that can be understood by a student who has strong knowledge of both the disciplines of math and dance. The writer is able to articulate how skill sets acquired in one discipline is helpful in another domain if the proficiencies are

complimentary to each other. The writer's comparison to 180 degree and the poses she dances to can be perfected with the figures she learns at school is an example of integrated learning that Noweck (2011) discusses.

*Being able to relate that aramandi is a diamond or that hand[s] joined together to say namaste form an isosceles triangle can help students grasp the different shapes and their abilities to transform much easier more so than when it is just a theory on a piece of paper. Since I am a very hand[s] on learner, dance has definitely helped reinforce those concepts (7).*

This dancer has the ability to compare the figures accurately with the dance poses she performs. The writer also acknowledges that she is a kinesthetic learner so dance has helped her to visualize diamond and isosceles triangle. This may be a call for teachers to use different methods while teaching geometrical shapes.

*Dance is an art form that strengthens the mind through repetition and concentration. In regards to teaching math concepts, many basic concepts of geometry found in the mudras and stances are repeated over and over in multiple dances so it gets better ingrained in the mind. The more someone is exposed to something the easier it is to remember and later understand, as is the case I found for myself in math (15).*

The above description deals with the student's focus on the retention aspect. Both math and dance require practice and repetitive working-out of problems and watching and performing the formations respectively. This writer is able to recognize the different shapes formed in different *mudras* or poses in *Bharatanatyam*.

The following table explains the first two steps involved in categorical analysis process of data. The texts from the participants are classified using Piaget's stages of cognitive development and the researcher has recorded her inferences based on the participants' interpretations of school practices and knowledge transfer (Table 3).

The only computation this study uses is the number of times each participant identifies a geometric shape in the dance. Five of the participants listed all of the shapes from simple to complex. However, five of the writers recorded rectangle as parallelogram. Only five were able to identify the shapes in the concrete operational level and five could do the formal operational thinking by including trapezoid, diamond, acute and obtuse angles, rhombus, and hexagon. Next, I tallied the geometrical shapes by recording all of them. Out of the total twenty participants, I was interested in finding out how many participants recognized all of the shapes.

## FINDINGS

It was clear through data analysis that students appreciated the integration of math and dance in learning the basic geometric shapes. Students recognized the value of incorporating a cultural out-of-school activity to learn a content area (math) because these children were able to recognize the connection between the skill set common to math and dance. Several participants pointed out how teaching styles did not match with the learning needs of students, especially those who were experienced with culturally contextualized dance called *Bharatnatyam*. The study also enabled the researcher to

**Table 3.** Phrases and classification.

<b>Exemplars</b>	<b>Classification</b>	<b>Researcher's Inference</b>
<i>Lines and diagonal...It is fun to learn math using dance that is not done in school.</i>	Pre-operational	School practice as mentioned by the study participants
<i>Angles and lines all over...Dance helps me memorize the angles and lines.</i>	Pre-operational	Transfer employed by few of the participants
<b><i>Math is boring because the teachers write on the board or talk all the time.</i></b> <i>If dance is used then we have to move and there will be excitement in class.</i>	Concrete-operational	School practices and learning style as observed by the study participants
<i>Bharatanatyam is about having straight lines. So when it came to having a good posture, I would look in a mirror and make my arms 180 degrees or make sure my poses looked straight like the shapes that we learned in school.</i>	Formal-operational	Transfer and scaffolding realized through years of practice of math and dance

gauge the relationship between perceptive, kinesthetic, and visual spheres of learning and the heightened level of knowledge formation through the integration of dance and math. Along with traditional methods of learning math, Asian Indian children expressed their willingness to learn geometric shapes through math and dance integration. This integration was possible through socio-cultural learning (Vygotsky, 1978), multiple intelligences (Gardner 1999), and integrative learning (Nowcek 2011; Zuckerbros, 2011).

## Conclusion

A preliminary inquiry of *Bharatnatyam* students' perception of integrating mathematics and dance suggested that Asian Indian American students could learn math through culturally specific dance called *Bharatnatyam*. The participants described their willingness to learn through transmediation and not merely through linguistic modes of instruction. The study also revealed how Asian Indian students can reiterate math concepts through *Bharatanatyam*. According to one of the study participants, it is easier to visualize than just listen to material presented to her,

*" Being able to relate that aramandi is a diamond or that hand[s] joined together to say namaste form an isosceles triangle can help students grasp the different shapes and their abilities to transform much easier more so than when it is just a theory on a piece of paper. Since I am a very hand[s] on learner, dance has definitely helped reinforce those concepts" (15).*

## Biases

This study was conducted out of school with students

from one cultural group that is marginalized in the US. This may create some biases in the participant selection, which may differentiate them from their classmates at school. The following biases are noteworthy- (a) The participants have parental and community support when they perform and they are provided with the tools necessary for success. (b) The participants' parents are either professionals or have successful careers. Parents take their children to dance class for cultural preservation. (c) Most of the participants dance or watch their siblings and friends dance. (d) This current study favors students who have the deep firsthand knowledge of *Bharatanatyam* and they may have approached the study with a fair knowledge of the dance. In addition, Asian Indian students have a reputation of excelling in Science Technology Engineering Mathematics (STEM) fields. Therefore, this study's findings cannot be generalized, but the study may be informative to researchers and teachers interested in the integration of dance and math disciplines.

## IMPLICATIONS AND LIMITATIONS

The integration of math and dance encourages teachers to rethink their approaches to teaching content area (geometry) utilizing aesthetics (dance), especially for those students who engage in out-of-school cultural art activity. Schools should consider investigating a variety of ways how culturally relevant practices such as *Bharatnatyam* could be exploited so diverse students including the Asian Indian American can benefit. According to Moore and Linder (2012, 108), "...the arts are inherently connected to other domains of knowledge and therefore are disconnected at the expense of the intimacy between the arts and other domains." The combination of *Bharatanatyam* concepts that support



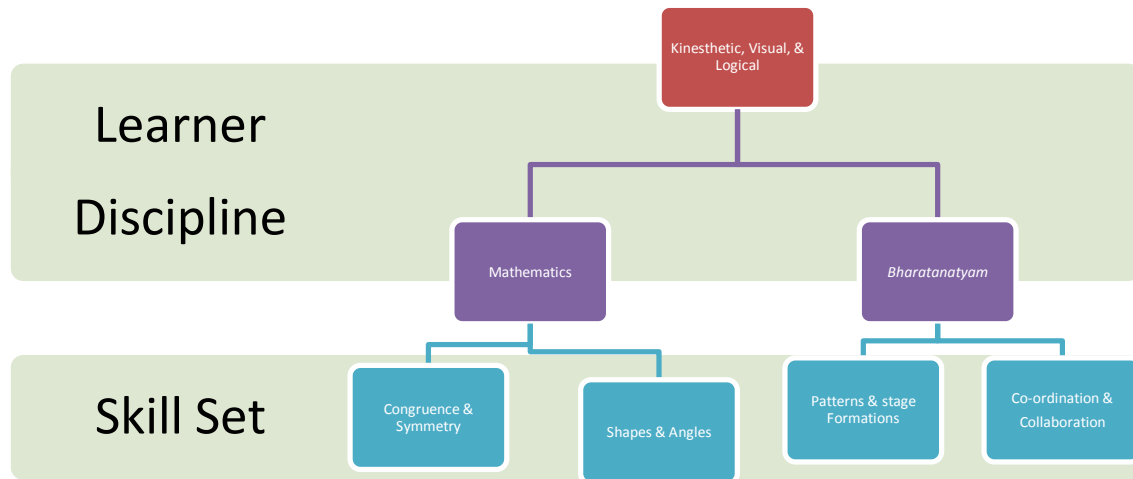


Figure 2. Mathematics and *Bharatanatyam*.

math concepts as described through the analysis of the data in this study help with understanding of the integration of dance and math as informative and perceptive. Students who are bodily-kinesthetic, visual, and logical learners are able to master concepts or skills common to math and dance. Dancers must become proficient with patterns and different stage formations while performing and students of mathematics must master skill set used in problem solving such as congruence, symmetry, shapes, and angles. The following figure depicts the relationship between learning styles in math and dance (Figure 2).

The limitations of the study are – (a) few participants, (b) the use of *Bharatanatyam* and no other dance styles, (c) the study's duration, and (d) sequential mixed methods analysis design. A follow up study with more number of participants will yield better results. Other dance forms such as Flamenco, Hip-hop, and Ballet may be considered for comparison because the study was conducted in the US. This study was done within a short period of time and studying students engaged in learning math utilizing dance for a longer duration would also help in understanding the learning processes. Finally, a quantitative analysis of data with control groups may provide improved results.

### Conflict of Interests

The authors have not declared any conflict of interests.

### Acknowledgement

I thank Dr. Wendy Oliver (Providence College) and Dr.

Howard Smith (University of Texas at San Antonio) for their constructive criticism.

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## Appendix A

Requisition Letter

From: Dr. M. Iyengar  
[yadugiri@hotmail.com](mailto:yadugiri@hotmail.com)

To: Mrs. Savitha Shastry  
[savitha@savithasastry.com](mailto:savitha@savithasastry.com)

Subject: Request  
Date: Tue, 21 Oct 2014 23:26:16 +0000

Dear Smt. Shastry,

My name is Dr. Dr. Iyengar and I am a postdoctoral researcher at the University of Texas at San Antonio. I need your permission to use this video in my study titled, "Teaching Geometrical Shapes Using Bharatanatyam". I've played this video to my college students when I teach how dance can be used to teach shapes etc. Kindly let me know if you have a non YouTube copy of this particular clip?

<http://youtu.be/SqilLOzFQh14>

Thank you.

Dr. Iyengar

Smt. Shastry's Response

"It will be a pleasure to have my work used to help students..."

## Appendix B

Recruitment Flyer

Dear Parents,

My name is Dr. Iyengar, and I am a postdoctoral researcher in the department of Interdisciplinary Learning and Teaching at the University of Texas at San Antonio. I am conducting a research study about "Teaching Geometric Shapes Using *Bharatanatyam*". Please contact me at [yadugiri@hotmail.com](mailto:yadugiri@hotmail.com) if your child, with you permission, is interested in participating in the study. I will send you the details of the research project along with the consent forms. I appreciate your willingness to help me in this research study. The dance and music schools are only responsible for disseminating this recruitment request letter. They cannot clarify anything about this research project, so please direct all your inquiries to Dr. Iyengar.

**Title of the Research Study:** Teaching Basic Geometrical Shapes Using Bharatanatyam.

**Purpose:** The purpose is to investigate and conduct a mixed methods research study to answer the following hypothesis- *Bharatanatyam is an engaging modality to teach geometric shapes because this dance accommodates the different kinds of learners including logical/mathematical, visual/spatial, bodily/kenesthetic, and musical/rhythmical.*

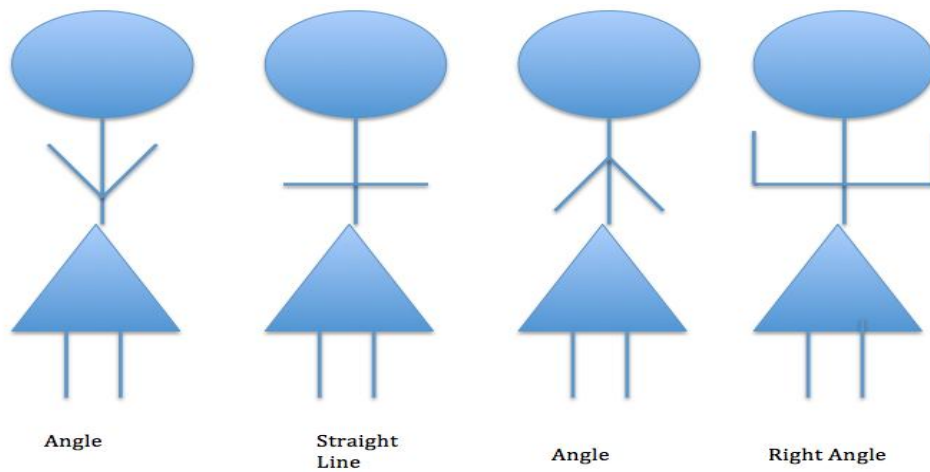
**Goal:** The goal of this study is to contribute to the existing literature on teaching Math using dance. Asian Indian American culture is not well addressed in American classrooms because of lack of awareness about the culture, lack of access to Asian Indian literature and cultural devices, and lack of trained teachers in schools in the US. This study will help the researcher to explore the significance of such pedagogy in scaffolding Asian Indian American students. The following questionnaire will be used to solicit responses after your children watch a 5-minute video on "Jathi" By Mrs. Savitha Shastry, a *Bharatanatyam* dancer. The participants will be asked to watch a short video and answer a questionnaire along with identifying the different shapes they can learn through *Bharatanatyam*. The following is an illustration of the survey.

<p>1. What different geometric shapes did you observe/identify in the Jathi? Name all of them.</p>	<p>2. Do you learn Math using dance at school? Write a brief description about learning math using Bharatanatyam after you watched Mrs. Shastry's "Puishpanjali."</p>	<p>3. Do you think you can learn Math using dance? Explain why or why not.</p>
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Please remember that the UTSA or *Bharatanatyam* dance schools are not responsible for any commitment. Your obligation in this research project is voluntary and is entirely your willingness to participate. Also, please do not feel compelled or harried to volunteer your children. You may withdraw your child anytime from the study as well. We would like to thank you in advance for your interest and time, and we look forward to your participation. Please feel free to contact Dr. Iyengar at [yadugiri@hotmail.com](mailto:yadugiri@hotmail.com).

Dr. Kalpana Mukunda Iyengar  
 San Antonio Writing Project Co-director &  
 Postdoctoral Researcher  
 Department of Interdisciplinary Learning and Teaching  
 University of Texas at San Antonio

**Appendix C : A Few Basic Shapes**



**Appendix D**



A *Kalakshetra* Dancer from *Kamala Keshava* Trust, Bengaluru, India.



A *Natyanjali* Dancer from Smt. Bana Shastri Ramanath's School, USA.