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# Concept Raps versus Concept Maps: A Culturally Responsive Approach to STEM Vocabulary Development

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**Abstract:** This article argues that the development of rap song lyrics or lyrical concept mapping can be a viable pedagogical alternative to the development of concept maps as a means to reinforce STEM vocabulary. Hip-hop pedagogy is a culturally responsive pedagogy that leverages the funds of knowledge acquired from hip-hop culture. Unfortunately, many students with strong hip-hop cultural identities may lack equally strong mathematics identities. Given the success of hip-hop pedagogies within the science content area, we posit that hip-hop pedagogies are appropriate in other STEM content areas such as mathematics. Concept mapping is an instructional tool that has been empirically validated as an effective means to develop strong conceptualizations of mathematics content. While hip-hop pedagogy is well established in the science content area, it remains underdeveloped within mathematics education. We argue that the lyrical structure of a rap song is fundamentally similar to the structure of a concept map. This article provides a framework to support lyrical concept mapping as a culturally responsive instructional tool that can be used as an alternative to traditional concept mapping. Special attention is placed on the use of hip-hop pedagogy to affirm and empower dually marginalized students.

**Keywords:** hip-hop pedagogy; concept maps; vocabulary development; STEM

## 1. Introduction

Vocabulary development is essential to conceptual understanding and sustained disciplinary knowledge in Science, Technology, Engineering and Mathematics (STEM). "Vocabulary is at the surface level of language usage; thus, students need to develop mathematical and scientific vocabulary to be able to explicitly communicate their mathematical and scientific reasoning with others" [1] (p. 69). Therefore, a lack of vocabulary mastery can pose a significant challenge for student achievement in STEM. For instance, data suggest that underachievement in STEM content areas is often the result of acute challenges related to a lack of fluency and understanding of fundamental STEM vocabulary [2,3]. Increasing the number of culturally and linguistically diverse STEM professionals remains a challenge for educators, businesses and our nation.

Many underrepresented populations of learners have tremendous STEM potential that remains untapped due to the cultural discontinuity that can exist between the student and traditional pedagogical approaches to STEM content or instruction. Culturally informed practices, such as

hip-hop pedagogy, are proffered as a means to overcome the instructional challenges of these and other cultural discontinuities in the mathematics classroom. We argue that the lyrical structure of a rap song is fundamentally similar to the structure of a well-defined concept map. Therefore, this article provides a framework to support lyrical concept mapping as a culturally informed instructional tool that can be used as an alternative to traditional concept mapping. Special attention will be placed on the use of lyrical concept maps to address challenges related to vocabulary development in mathematics.

The National Council of Mathematics Teachers (NCTM) has placed a renewed interest in the development of effective mechanisms to increase access and equity within all mathematics classrooms. As such, the Access and Equity Principle explicitly encourages teachers to become more responsive to students' backgrounds, experiences, cultural perspectives, traditions and knowledge when designing and implementing a mathematics program and assessing its effectiveness [4] (p. 1). Likewise, NCTM has consistently advocated for an increased focus on mathematics disciplinary vocabulary development. For example, "communication is an essential part of mathematics," therefore, students need opportunities to use writing to express mathematical ideas [5] (p. 60). Hence, merging culturally informed tasks that incorporate writing skills represents a plausible pedagogical practice that can yield meaningful changes in student engagement and achievement in mathematics.

Hip-hop includes four pillars: rapping, deejaying, breakdancing and graffiti art [6,7]. Dimitriadis, Cole and Costello indicate that hip-hop culture is the medium that informs how youth construct their identities and social networks [6]; this embodies a notion of a fifth, often less noted pillar of hip-hop that is referred to as Knowledge of Self [7]. Hip-hop pedagogy leverages student cultural funds of knowledge to foster a deeper understanding of complex ideas and information by drawing connections to the cultural norms of the growing international hip-hop society. Hip-hop pedagogy is hence considered to represent a natural extension, adaption or remix to the established culturally responsive pedagogical practices [8,9]. Authentic implementation of culturally relevant or culturally specific pedagogies and their applications in Science, Technology, Engineering and Mathematics (STEM) classrooms remain relatively absent from professional practice. However, intersections exist between hip-hop identity and mathematics identity, which can potentially carve out an academic space for creativity, social justice, and strength-based instructional practices that reflect authentic cases of culturally sustaining pedagogies within the mathematics content area. The authors provide a more thorough discussion of hip-hop pedagogy and its foundations in hip-hop more generally within the body of this paper.

Many critics of culturally informed pedagogies cite that many of the proposed approaches lack practicality. The translation of culturally responsive teaching from theory to practice is difficult for the majority of classroom teachers. This perspective is substantiated by self-efficacy data that suggest that both in-service and pre-service teachers lack the culturally responsive teaching self-efficacy (CRTSE) to execute culturally responsive practices in their classrooms [10,11]. Appropriately, it is important to build connections between practices that are familiar or well established within the discipline. Concept mapping represents a pedagogical practice that has documented success across multiple STEM content areas and is relatively commonplace in most teacher education and professional development activities. The substantial uptake and acceptance of concept mapping provides an ideal pedagogical strategy to bridge connections between traditional STEM teaching approaches and hip-hop pedagogies.

Hip-hop pedagogy is one means to increase access and equity in the mathematics classroom by leveraging hip-hop identities to foster mathematics identities. For the purpose of this discussion, we argue that many mathematically disenfranchised youth are rich in hip-hop cultural capital that can be harnessed as a transformational instructional tool. However, this transformation requires more pedagogically specific "high expectations and strong support for all students" [12] (p. 8). The guiding principles for school mathematics state "[a]n excellent mathematics program requires that all students have access to a high-quality mathematics curriculum, effective teaching and learning, high expectations, and support and resources needed to maximize their learning potential" [13] (p. 5). This suggests that to be considered excellent, a mathematics program must meet the instructional needs of all students by providing the support and resources necessary to build their mathematics capacity.

## 2. Purpose

The purpose of this article is to provide an explicit pathway between hip-hop pedagogy and formal mathematics instruction. Concept mapping is an established instructional tool that has been empirically validated as an effective means of developing strong conceptualizations of mathematics content. Consider the wealth of research supporting the benefits of concept mapping as an instructional support for relational understanding, and then, consider if you could repackage this tool to make it not only accessible to, but a strength of traditionally underserved youth. We propose that a rap is simply a "lyrical concept map" within which a central concept is connected by verses and summarized by the hook.

Here we posit that lyrical concept maps or concept rapping can serve as a conduit between traditional pedagogical approaches to STEM disciplinary vocabulary development and emergent approaches such as hip-hop pedagogy. While hip-hop pedagogy is well established in the science content area, it remains underdeveloped in other STEM domains such as mathematics. Given the success of hip-hop pedagogies within the science content area, we suggest that hip-hop pedagogies are appropriate across Science, Technology, Engineering and Mathematics (STEM) content areas. In the discussion that follows, we explicate the importance of vocabulary development as a means to support achievement in STEM content areas. Then we argue that hip-hop lyrics are fundamentally similar to traditional concept maps. To facilitate this argument, we review the literature on concept mapping within the context of STEM. Then we examine the current effects of hip-hop pedagogy on STEM content learning. Lastly, we compare and contrast the structure of concept maps and the structure of rap songs to clarify the inherent connections between them to build a case for the consideration of lyrical concept maps as instructional tools within STEM education.

## 3. Vocabulary Development and STEM Achievement

Achievement in STEM content areas remains a challenge for many minoritized populations of learners. These achievement disparities jeopardize the nation's scientific, technology and engineering capacity. Thus, the shortage of women and other traditionally underrepresented populations is a well-known challenge [14]. According to data from the National Center for Education Statistics, low-income and minoritized youth lack foundational skills in STEM content [15]. One of these often-overlooked foundational skills is a strong grasp of STEM discipline-specific vocabulary. A strong disciplinary vocabulary is recognized as a key component of achievement and retention in STEM-related content areas. According to the NCTM Principles and Standards for School Mathematics, students should be encouraged and supported as "they communicate to learn mathematics, and they learn to communicate mathematically." [5] (p. 60). To edify this notion, intensive research conducted by Knuth and Peressini suggest students engaging in mathematical language increases their mathematical understanding [16]. Little is known regarding teachers' or even students' development of STEM-specific language across the individual content areas [17] (p. 188). For instance, very few measures exist to solely measure vocabulary understanding in mathematics and other STEM content areas [18]. However, there is mounting evidence that concept maps are effective tools for developing deep conceptual understanding in STEM content areas [19–21]. Concept maps also align with general recommendations for mathematics vocabulary development, which urges teachers to use varied approaches that utilize multiple representations [22].

Concept maps facilitate disciplinary literacy development, which is key to sustained achievement in STEM content areas. A disciplinary literacy approach emphasizes the knowledge and skills possessed by practitioners as the knowledge is used in the field [23]. Concept maps represent an established vocabulary development tool utilized by STEM educators. Within most STEM content areas, and mathematics specifically, conceptual understanding is key to the discipline. Thus, students must understand more than the definition of a triangle, but rather, all of the geometric and measurement properties associated with all triangles. Hence, when a mathematician describes a triangle the definition goes beyond the obvious characteristics and focuses on the properties that can be used to identity all triangles, and well as the unique categories or different types of triangles. Concept maps are the

perfect tools to summarize, organize and represent this information in a meaningful way. In the next section, we review the literature on concept mapping in STEM and highlight the recent connections to mathematics content learning.4. Concept Mapping in STEM: Mathematics Connections.

Graphical representations of concepts and data have a long history in the educational literature. For example, flow charts, pie charts, and other visual data displays date back to the early 1970s [24]. Concepts maps represent one of several visual display tools that can be used to present connections between concepts and ideas. Other mapping processes include mind mapping and argument mapping. Concept maps are described as graphical representations for organizing and representing knowledge. According to Davies, concept maps are relational devices that use a hierarchical "tree" structure with super-ordinate and subordinate parts (primary, secondary and tertiary ideas) [25]. Concept mapping as an instructional tool helps students to visualize the structure of knowledge. The concept map was originally developed as a means of representing frameworks for the interrelationships between concepts. However, the concept map can be utilized as an assessment tool to facilitate the meaningful assessment learning [26]. Today, concepts maps are used across multiple content areas and have shown positive effects on student learning outcomes.

The literature on the use and effects of concepts in STEM content areas is vast. Concept maps are consistently recognized for their ability to help students develop a greater conceptual understanding of content compared to more traditional methods such as reading textbooks, listening to lectures, or taking notes [27]. This is often attributed to the notion that pictures or diagrams are more comprehensible than words, and often provide a clearer illustration of complex topics [28]. The effects of content mapping on student information retention are also attributed to map development process. Accordingly, concept maps have been used to assess changes in student conceptual understanding. In their seminal study, Wallace and Mintzes observed that students' concept maps were substantially different in complexity and structure of the knowledge base from the pre-test to the post-test [29]. This led the researchers to conclude that concept mapping is a valid tool to document students' changes in conceptual understanding. The effects of concept maps on student learning outcomes have been documented in several meta-analyses and research syntheses [30,31]. The results of these literature syntheses consistently conclude that concept maps are more effective than traditional interventions such as note-taking or direct instruction.

Concept mapping is an established pedagogical practice within the STEM content areas. Concept maps are recognized as effective instructional tools for the development of relational understanding in the mathematics classroom [32]. Concept maps are effective tools for previewing or reviewing a topic, formal or informal assessment, facilitating classroom discourse, and providing visual representations of mathematical connections [33]. Therefore, concept maps are utilized in many mathematics classrooms to develop student conceptual understanding. One key to a strong conceptual understanding of mathematics is a rich and fluid mathematics vocabulary.

## 4. Hip-Hip Pedagogy in the STEM Classroom: Mathematizing Hip-Hop

As alluded to in the introduction, hip-hop pedagogy translates naturally into the STEM classroom through a culturally relevant pedagogical lens that seeks to infuse the elements of hip-hop culture into teaching, learning and assessment. Beyond the five pillars of hip-hop, other elements of the culture include fashion, street language, spoken word poetry, beat boxing, entrepreneurialism and activism. Creative expression is central to forming the beliefs and customs within hip-hop culture. Hip-hop culture, that which precedes the pedagogy, was born in the Bronx in the mid-1970s and is now a global phenomenon that has spread to all corners of the world [34]. Hicks Harper noted the complexity and shifts that happen in hip-hop as youth culture changes, yet it is the global power and consistent elements of hip-hop that continue to influence the attitudes and choices of students Emdin and Lee and Ortiz contend that hip-hop serves as an outlet for youth, who have been disregarded and devalued, to share with others who have similar experiences [35–37]. Hip-hop identity is commonly perceived as an anti-school identity, and addressing this issue will require a shift in focus to hip-hop culture as valuable for education.

The necessity of hip-hop pedagogy is evident when one considers the origins of mathematics education and the mathematics teaching that has been normalized in U.S. schools. Traditional pedagogy often fails to account for students as contributors, and rarely considers their interests in the lesson design. Learner interest matters in the classroom, as it promotes engagement, motivation and "stick-with-it-ness." The disconnect is particularly detrimental to marginalized Black and Brown students whose interests have often been characterized as unsuitable for the formal educational setting; thus, the subtractive, intolerant nature of traditional instruction ignores their intellectual potential. Whereas, hip-hop pedagogy is unabashedly progressive, deliberate in its outreach to its targeted audience, marrying the students' culture/interests, in this case, with mathematics in a most Deweyian fashion. Hip-hop pedagogy affords students the ability to use their interests and activities from the outside, bridging the gap between school and society and blurring the lines between traditional schoolhouse curricula and schooling that occurs outside of the school [38,39]. This juxtaposition offers insight into exactly how hip-hop pedagogy can impact the experiences that children with hip-hop identities have with mathematics. Additionally, hip-hop pedagogy represents a unique application of culturally responsive and relevant teaching. This is important because it adds further credence to the utility of hip-hop pedagogy. Gay defined culturally responsive teaching as understanding students' prior experiences and learning styles, as well as using cultural knowledge to ensure that learning is appropriate to culturally diverse learners [40]. While, Ladson-Billings defines culturally relevant pedagogy as pedagogy of opposition not unlike critical pedagogy, but specifically committed to collective, not merely individual, empowerment [41]. Hip-hop pedagogies utilize these elements to support the teaching and learning of traditionally marginalized youth.

A strong component to attending to these funds of knowledge is the development of a strong mathematics identity in students who are traditionally underserved in mathematics classrooms. According to Martin, "mathematics identity refers to the dispositions and deeply held beliefs that individuals develop, within their overall self-concept, about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives" [42] (p. 206). Hip-Hop identity formation frames the lens through which a multitude of ethnically and socially diverse youth and young adults view the world and themselves. Adjapong recommends that STEM educators participate in co-generative dialogues, or co-gens, as cyphers. He believes that in order to implement hip-hop pedagogy effectively, these educators should engage in co-gens with their students because this forum serves several purposes: collective decision-making, differentiation, equity, and feedback on the implementation of hip-hop pedagogical approaches like content raps [43].

## 5. Concept Maps vs. Concept Raps

Concept maps are built by placing terms, which represent the concepts to be mapped, in structures called nodes. The nodes, which are linked together into propositions, show how students connect or link concepts. The propositions are represented by arrows to connect individual concepts. An arrow indicates the directionality of the link. The conceptualization of the materials by the students is indicated by the directionality and the connecting proposition [44]. The proposition thus illustrates the contextual relationship of the concepts to each other. Concept maps and rap songs share four elements in common. Both include: the main idea or major point for consideration; a series of connections to the main idea; explicit explanations/elaborations on the relational structure of the main idea; and a formal organizational structure that users recognize.

The main idea in a concept map is the concept, while the song title is typically recognized as the main idea in a rap song. Connections to the main idea are made through linking words in concept maps and the hook in a rap song. The next common element is explanations/elaborations that come in the form of semantic units in concept maps and as verses in rap songs. Table 1 presented below provides a detailed comparison of the similarities between concept maps and rap songs on the four common elements identified.

**Table 1.** Description of common elements present in concept maps and rap songs.

| Elements | Concept Maps | Description | Rap Songs | Description |
|---|---|---|---|---|
| Main Idea | Concept | Central idea or key notion | Song title | Song content or purpose (intro/outro) |
| Connections | Linking Words | The relationship between the two nodes of concept map | Hook | Relationship between song title and verses (8 bars in length repeated) |
| Explanation or Elaborations | Semantic Units | Meaningful statements made up of two or more concepts connected with linking words | Verse | Rapping segment of hip-hop song that clarifies and provides context (16 bars) |
| Organization | Hierarchical Structure | The most general and inclusive concepts are positioned at the top of a concept map, following by subordinate ideas | Alternating Pattern | Intro<br>Hook<br>1st verse hook<br>2nd verse hook<br>3rd verse outro<br>(Can vary across songs) |

The challenge for some STEM educators in regard to embracing content raps will lie in their willingness to realize their miseducation, even their own biases, and reject research about vocabulary development and economically marginalized children of color. This position is important, as 80% of teachers in the United States are White, middle-class individuals with limited experience of culturally and linguistically diverse students. Moreover, according to the National Science Foundation, STEM is a field dominated by White men. In 1995, researchers Hart and Risley released their book *Meaningful Differences in the Everyday Experience of Young American Children*, which contained their well-known study on the 30 million-word gap between the vocabularies of three-year-olds in "welfare" and working-class families as compared to their White counterparts in professional families. The study was not published until 1992, but their findings reached wider and more influential audience after the publication in their book and have shaped educational policies, pedagogical practices, and parenting initiatives to this very day. Initial reactions to the word gap sparked positive changes such as federal investments in early childhood intervention programs like Head Start. However, despite the fact that this study's findings have not been replicated in the last twenty-six years and current researchers have discovered that the gap is closer to 3 million, the long-term, long-lasting result has been deficit thinking about the ability of Black and Brown children to handle complicated subject matter due to subpar vocabulary development.

There is no doubt that there is a link between vocabulary and comprehension and thereby achievement. What some failed to do is understand that learners of color actually possess word wealth, which is experienced by children who grow up in homes where a different dialect or language is spoken versus the dominant Standard English of school [45]. It is not that these children are not prepared for traditional education. Just the opposite. Traditional education is not prepared for them. That is why STEM educators' appreciation for content raps is advised. They must initially expect a cultural mismatch between students of color lexicon and the academic vocabulary in STEM content areas. However, vocabulary development and growth will depend largely on the teachers' ability to support the role that formal and informal substitutions, analogies, synonyms, multiple meaning words, and inference play in bridging the connection between personal and academic words in the classroom. Dando cautions educators to see hip-hop as more than a motivator to engage students, but rather to use hip-hop, such as with content raps, to generate new ways of thinking.

## 6. Discussion

As Emdin addressed in his book, some practitioners are resistant to using hip-hop as a pedagogical tool [46]. One misconception is that teachers have to be masters of the art to utilize it effectively. However, this directly contradicts the need to use this alternative form of pedagogy, for which the intent is to privilege the knowledge that students bring into mathematics classrooms. In seeing that the expert role no longer belongs exclusively to the teacher, students begin to view the classroom as a place in which they are valued and seen as competent. Still, others view hip-hop pedagogy as a waste of time and disparage its utility, yet no strategy that motivates greater populations of children to achieve in mathematics should be regarded as a waste of time or effort. Here are some of the common challenges to the use of hip-hop pedagogy in mathematics classrooms. First, many teachers may struggle to garner administrator support for implementing hip-hop pedagogy. Principals are charged with ensuring that instructional materials are research-based, age-appropriate, and free of bias. If the principal cannot appreciate the value of hip-hop in the classroom, the teacher will find it very difficult to obtain its approval.

Secondly, novice implementers may misinterpret the utility of the practices and cause student confusion. This is not a challenge that is unique to hip-hop pedagogy, but it can be more pronounced if the teacher does not have to be an expert, but he or she must have a clear and sound understanding of hip-hop pedagogy to use it effectively. Much like all classroom interventions, teachers will have to overcome time constraints when considering hip-hop pedagogy. Most teachers are guided by scope and sequence or pacing calendar and are given a certain amount of days to cover a specific skill or concept.

Depending on the time allocated to a particular standard, teachers may be forced to choose between hip-hop pedagogy and traditional methods. Differentiation can also be challenging when teachers first consider hip-hop pedagogy. The teacher may struggle to find ways to use hip-hop pedagogy with all learners, especially those at risk with moderate-to-severe delays in basic mathematical literacy and computation skills. Finally, the excessive use or misuse of hip-hop pedagogy can create major challenges for the student that does not engage in hip-hop culture. As hip-hop pedagogy becomes the new shiny toy in education, educators must be cautioned against using it haphazardly, trying to make it fit where it does not, or overusing it to the point that it dulls students' interest and attention in the way some forms of technology have.

## 7. Conclusions

Meeting the needs of current and future STEM learners remains a challenge for educators and researchers. Appropriately, many argue that developing effective STEM education is one of the most significant challenges facing educators [47]. Here we have urged educators and researchers to consider diversifying their pedagogical approaches to reach a more diverse population of STEM learners. Specifically, we have argued for hip-hop pedagogy and culture to be employed to engage underrepresented students in mathematics and other STEM content areas. This shift, however, requires a focus on hip-hop in mathematics curricula that requires educators to recognize that both mathematics and hip-hop have shared elements. For example, mathematicians search for patterns to solve problems and create models. For example, hip-hop artists create patterns in their music to generate new and unique sounds, while mathematicians utilized numerical patterns to solve complex problems. Finding authentic ways to spark student interest in mathematics requires educators to stay current with youth culture and recognize hip-hop pedagogy as a viable instructional resource. Here we present one pedagogical connection; however, hip-hop pedagogy should not be limited to this one example. We hope that teachers and teacher educators will embrace hip-hop pedagogy as a culturally responsive instructional tool for the hip-hop generation and beyond.

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