Dance and Vlogs: Creating Pathways to STEM Identity for Marginalized Girls

by

Amy Nathan

A Project submitted to the School of Graduate
and Postdoctoral Studies in partial fulfillment
of the requirements for the degree of

Master of Education

Faculty of Education
University of Ontario Institute of Technology (Ontario Tech University)
Oshawa, Ontario, Canada

March, 2024

Project REVIEW INFORMATION

Submitted by: **Amy Nathan**

Master of Education

Dance and Vlogs: Creating Pathways to STEM Identity for Marginalized Girls

The Project was approved on March 22, 2024 by the following review committee:

Review Committee:

Research Supervisor	Dr. Robyn Ruttenberg-Rozen
Second Reader	Dr. Anna Rodrigues

The above review committee determined that the Project is acceptable in form and content and that a satisfactory knowledge of the field was covered by the work submitted. A copy of the Certificate of Approval is available from the School of Graduate and Postdoctoral Studies.

ABSTRACT

Girls tend to start losing interest and confidence in their STEM talents in their adolescence and start dissociating themselves away from STEM. Research shows that alternative learning practices have been useful and been able to increase STEM exploration, engagement and support STEM learning. In this paper, I explore the impact of STEM learning from two alternative practices: dance and video logging to determine if there is a connection to STEM identity development of marginalized girls.

Keywords: STEM identity; dance; video logging; girls

AUTHOR'S DECLARATION

I hereby declare that this project consists of original work of which I have authored. This is a true copy of the work, including any required final revisions, as accepted by my committee.

I authorize the University of Ontario Institute of Technology (Ontario Tech University) to lend this work to other institutions or individuals for the purpose of scholarly research. I further authorize the University of Ontario Institute of Technology (Ontario Tech University) to reproduce this work by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research. I understand that my work may be made electronically available to the public.

Amy Nathan

ACKNOWLEDGEMENT

I would first like to acknowledge and thank my supervisor Dr. Robyn Ruttenberg-Rozen for not only being a great supervisor, but an amazing mentor to me over the past two years. I am grateful for your guidance. I would also like to thank my friends, I appreciate your advice and support throughout this process. Finally, I would like to thank my family: my parents, brother, godparents, grandmas and my aunt Maureen for your patience, understanding and encouragement through my pursuit of graduate studies. I am truly blessed to have your love and support.

TABLE OF CONTENTS

Chapter 1. Introduction

Women in Science, Technology, Engineering, and Mathematics (STEM) education can face marginalization through barriers that make access to services and equitable opportunities more difficult. These barriers can include cultural incongruence (Crenshaw, 2015; Exarhos, 2020; Johnson et al., 2011; Steinke, 2017), feelings of isolation, stereotypes that women do not belong in STEM (Diamond & Stebleton, 2019; Johnson et al., 2011; Starr, 2018; Steinke, 2017) and experiences of discrimination in the workplace (Crenshaw, 2015; Diamond & Stebleton, 2019). In particular, the effects of these barriers are often exacerbated for women of color in STEM. This is because the effects of marginalization of each identity (gender and race) compound (Hachey et al., 2022; Johnson et al., 2011; Ortiz et al., 2020). There are different degrees of effects of this compounding, and students of Indigenous, Latinx and Black racial identities have been recognized as the most underrepresented and racially minoritized groups (Diamond & Stebleton, 2019; McGee, 2020).

Kimberlé Crenshaw (2015) uses the term “intersectionality” to describe the vulnerabilities certain groups of people have faced because of their multiple social identities. The intersection of race and gender has disadvantaged women and as a result, women have had more challenging journeys to be considered a STEM person (Johnson et al., 2011; Rodriguez et al., 2021). Women have reported experiencing inner turmoil when consistently faced with choosing between their cultural identity and fitting their STEM academic surroundings (Carlone & Johnson, 2007; Exarhos, 2020). This turmoil leads to a continuous battle between the female students’ social identities. One outcome of this battle is identity disruption, which leaves the individual feeling disconnected and disappointed. Through repeated disconnection and lack of inclusion and belonging, women can then leave STEM environments (Carlone & Johnson, 2007). These additional barriers have created a leaky pipeline. The leaky pipeline has been used to describe URM women as they become lost or discouraged at various points in their

STEM journey. The leaky pipeline shows the “leaks” as women leave STEM as a result of this discouragement. However, it should be noted that the metaphor of leaky pipeline is limited because it implies that there are multiple exit points but only one entry point, making reentry difficult for these women (Hachey et al., 2022; Johnson et al., 2011; Ruttenberg-Rozen et al., 2022; Steinke, 2017). Women are often faced with the difficult decision of choosing to persevere and face the obstacles or leave their STEM field (Carlone & Johnson, 2007; Hachey et al., 2022; Johnson et al., 2011; Steinke, 2017).

Feelings of belonging require engagement, imagination and alignment (Carlone & Johnson, 2007). In its absence, a lack of belonging can start to deter individuals from STEM as early as elementary school. If an individual does not participate in or engage in meaningful STEM exploration experiences in elementary school, it halts the process of creating a sense of belonging and initiating a STEM identity, a sense of being a STEM person. Research shows that by adolescence, more and more girls choose not to participate or engage in meaningful STEM explorations because they do not see themselves as STEM people (Kang et al., 2019; Ortiz et al., 2020; Speldewinde & Campbell, 2021). If they cannot imagine themselves fitting into a community of practice, then no alignment between their STEM and social identities can be made (Carlone & Johnson, 2007). Consequently, girls lose interest and confidence in their STEM talents as they start dissociating themselves away from STEM.

A prominent factor that causes girls to dissociate from STEM is stereotypical gender expectations (Hachey et al., 2022; Speldewinde & Campbell, 2021). Girls are flooded as early as kindergarten with subliminal messages that STEM is not for them. The subliminal messaging of gender role stereotypes includes even the toys in the learning environment, creating the presumption that girls should play with dolls and that tools are for boys (Speldewinde & Campbell, 2021). Messages like these create obstacles for girls, preventing them from exploring freely. There is enough evidence to support the lack of inclusion and belonging in STEM starts in elementary school for girls; girls have reported a lack of engagement in meaningful

experiences, and their efforts are not recognized by mentors or validated by meaningful people in their lives. For this reason, they then become less motivated to persevere and more likely to give up pursuing STEM. This narrows the options and choices girls, especially marginalized girls, have from a very young age. Restricting STEM exploration in elementary school creates a domino effect that results in limiting access to educational programs in higher education (Steinke, 2017) and also stifling future creativity and innovation.

In light of the limited access, elementary school programs have a responsibility to inspire and create a sense of belonging. A sense of belonging motivates, directs and focuses an individual's attention and efforts toward a subject area. Therefore, schools should be providing all students with as many new and innovative STEM learning opportunities as possible to allow them to make informed decisions about their academic futures. Engaging in a variety of STEM experiences that support acquiring a strong STEM knowledge base and include receiving positive reinforcement from significant people in STEM can support the development of STEM identity (Dou & Cian, 2021; Ortiz et al., 2020). Research shows that individuals can accumulate STEM experiences and start developing a STEM identity as early as kindergarten through play-based learning (Hachey et al., 2022; Speldewinde & Campbell, 2021). Researchers found that an early STEM experience can be created through informal STEM talk. These informal discussions with family and friends about STEM topics outside of the traditional school setting is a significant pathway to generating interest in STEM and fostering STEM curiosity in students (Dou & Cian, 2021). Therefore, the more informal and formal STEM experiences an individual has creates a strong foundation to bolster an individual's STEM identity (Carlone & Johnson, 2007; Hazari et al., 2010) and promote future engagement in STEM in higher education.

Subsequently, a lot of STEM learning can occur outside of traditional classroom practices. This is especially important for young women of colour, the group that is the focus of this paper. As discussed earlier, female students of colour have a long history of experiencing structural and institutional barriers due to racism and sexism (Exarhos, 2020; Runyan, A. S.,

2018). Alternative STEM practices can therefore be advantageous to female students of colour as they provide them with opportunities for STEM learning that are different from the traditional STEM learning.

In this paper, I explore the impact of two alternative practices, dance and video logging and how they are connected to STEM learning and identity. My interest in these two mediums is because alternative learning practices have been able to increase STEM engagement, support STEM learning and identity development. In exploring these, I endeavour to use an anti-deficit lens. In STEM classrooms, some terms, such as “underprepared" and “at-risk,” place a negative connotation on the individual and create a perception that the individual is unsuccessful because of their own intellectual deficiencies (Castro, 2014; Exarhos, 2020), thereby discouraging and deterring women of colour from pursuing STEM fields. The anti-deficit approach acknowledges the female students’ various social identities and shifts the focus back onto the social and structural barriers that people of colour have had to face. This way the focus and attention is on the persistence, development and achievement of women of colour. The anti-deficit approach in educational settings acknowledges the environment and resources of students as opposed to “fixing” the student (Castro, 2014; Ellis-Robinson, 2021; Exarhos, 2020). For this reason, implementing creative and dynamic practices that build STEM knowledge and understanding in elementary schools is essential. When students can make connections between themselves and the content, they can create a sense of belonging, thereby strengthening their STEM identity.

Chapter 2. Positionality

Discovering and developing new ways of connecting with and reaching adolescent students of colour is important to me as an educator. Identifying as a female and a visible minority, I am double-marginalized, enabling me to easily relate with the demography of my students; I am able to understand the plight that some of these students will face, having gone

through it myself. This has motivated me to determine new and inspiring ways of engaging and supporting the identity development of marginalized girls that I teach within the middle school learning environment.

I was motivated to find a way to support identity development because identity is dynamic; new experiences are continuously informing and developing our identity. Identity formation and development are pivotal during middle school for girls. Developing who they are and knowing what is important to them is at the core of their identity, and these young girls will not discover these things without access to new experiences. This is why access to educational STEM experiences is really important for girls at this age. These young girls need to have ample opportunities to experiment freely and learn from trial and error so that they can use the knowledge gained from lived experience to decide if they see themselves as STEM people. Having a strong foundation based on things that interest them will give them the confidence to seek out opportunities on their own and to continue to pursue STEM in the future.

Chapter 3. Identity Development in STEM

During adolescence, individuals are attempting to figure out what interests them, what is important and relevant to them, and to choose a potential future career (Kang et al., 2019). The decisions an individual makes during adolescence determine the “kind of person” they want to be (Gee, 2000, p. 99). Their actions, depending on the learning contexts and interactions with people they engage in, can change their academic path. Therefore, STEM identity development is important for the growth of a young female’s adolescent (Speldewinde & Campbell, 2021).

When an individual is able to see themselves as a STEM person. We say they have a STEM identity (Diamond & Stebleton, 2019; Dou et al., 2019; McClain & Colina, 2022 Speldewinde & Campbell, 2021). When someone has a STEM identity, then they are more likely to take the initiative to seek out and participate in experiences that are relevant and meaningful to them (Carlone & Johnson, 2007). The increased number of STEM experiences they have to

reflect on influences their sense of belonging to STEM. The three modes of belonging, engagement, imagination and alignment, are important factors for STEM identity development (Carlone & Johnson, 2007). When an individual engages in meaningful experiences, it allows them to see themselves fitting into a community of practice. Increased STEM engagement and envisioning allow an individual to align their actions in pursuit of a future STEM career based on their interests.

An individual's actions determine who they are and shape their identity. Many scholars agree with Gee (2000) that identity development is multidimensional and dynamic. Identity can be constructed and reconstructed to be adaptable to new social interactions (Avendano-Uribe et al., 2022; Carlone & Johnson, 2007; Gee, 2000; Smith et al., 2022; Steinke, 2017). Gee (2000) categorizes identity into four different perspectives:

- Nature identity, we are what we are because of our natures.
- Institution identity is the position we occupy in society.
- Discourse identity is our accomplishments recognized by others.
- Affinity identity is the experiences we have in a group.

Each process is not independent of the other but helps us understand the "kind of person" in any given situation (Gee, 2000, p. 99). Of the four, discourse and affinity identity have a significant role for marginalized girls in their pursuit of STEM.

A common factor in discourse and affinity identity is recognition. Recognition plays an important role for girls marginalized in STEM when they attempt to develop a STEM identity. (Dou & Cian, 2021). Recognition is a highly motivating factor in individuals, especially when it is accompanied by a sense of accomplishment. The more recognition people receive from others, the more they are encouraged them to seek out other academic opportunities. Carlone and Johnson (2007) highlighted the importance of the recognition dimension in developing a science identity. Numerous studies since have highlighted the significant role and impact of internal and external recognition has on creating and developing a STEM identity (Cohen et al., 2021;

Hachey et al., 2022; Hazari et al., 2010; Kang et al., 2019; Kelly et al., 2020; Ortiz et al., 2020; Speldewinde & Campbell, 2021; Steinke, 2017). Recognition cannot be a singular event to impact STEM identity development. Recognition has to be consistent and occur repeatedly for stronger identification and development of a STEM identity (Carlone & Johnson, 2007).

In particular, external recognition is what an individual receives from meaningful people in STEM to establish oneself (Diamond & Stebleton, 2019). External recognition can come from any STEM person the individual deems as worthy such as mentors, teachers and professors (Ortiz et al., 2020; Rodriguez et al., 2021). One of the earliest sources of external recognition, inspiration and emotional support can be accredited to the role family and friends play for an individual (Carlone & Johnson, 2007; Diamond & Stebleton, 2019; Johnson et al., 2011). Studies have demonstrated that early informal science talk with family members and friends has the potential to foster STEM curiosity and interest in an individual's formative learning years in elementary school (Dou & Cian, 2021). Informal science conversations with people who individuals look up to are impactful because the conversations can motivate and encourage them to get involved, seek knowledge or participate in new learning experiences in the future and affirm STEM interest (Dou & Cian, 2021). An individual's curiosity, desires and interests need to be supported and encouraged by meaningful people around them. What close family members think and value has the power to shape an individual's thought process and decisions. Researchers have indicated that persistence, college enrollment, career aspiration and intention are predictive of family discourse (Rodriguez et al., 2021). Researchers have reported that the informal discussions the participants had not only supported STEM identity formation and development but also gave them the confidence, agency, motivation and courage to seek out and explore different STEM avenues in higher education (Dou & Cian, 2021).

Individuals should be provided with ample STEM learning opportunities for identity exploration so that commitment to STEM is easier to achieve (Steinke, 2017). Research (Kelly

et al., 2020; Steinke, 2017) shows that four identity statuses have been identified in relation to the extent of exploration and commitment an individual has, namely;

- identity achievement,
- identity moratorium,
- identity foreclosure, and
- identity diffusion.

The successes and failures individuals face as they learn and develop helps to shape them and plays a role in who they will become. Students should be provided with a variety of hands-on learning experiences, allow them to explore and shape their learning and identity so that commitment is easier to attain (Kelly et al., 2020; Steinke, 2017). In the next section, I discuss traditional practices of teaching and learning in STEM, as well as practices that support the identity development of learners historically marginalized in STEM.

Chapter 4. Teaching and Learning for Learners Historically Marginalized in STEM

STEM education can involve a more hands-on, or experiential, approach to learning. Experiential learning can be divided into two main categories; field-based experiences and classroom-based learning (Schwartz, 2012). Field-based is the oldest and most established form of experiential learning that has been integrated into higher education; some of the different forms are internships, cooperative education placement, practicums, hands-on laboratory activities and field studies (Chan, 2012; Schwartz, 2012). The common forms of classroom-based experiential learning activities include role-playing, games, presentations and group work. However, experiential learning is starting to take different forms in K-12; it can look like cooking, sewing, welding, robotics, painting, printing and building (Hsu et al., 2017). These type of experiential activities allows students to learn through hands-on activities by shifting the roles of teachers and students to become more student-centered. Student-centered activities are more interactive and meaningful for learners because they are often participating in

real-world activities. Experiential learning allows students to utilize and transform the lessons they have learned from textbooks into active understanding, which leaves a deeper and long-lasting impression (Chan, 2012).

Student-centered experiential learning is based on the learning theories of Piaget, Kolb and Dewey, that encourages learning by doing. They viewed the nature of experience as continuous, and with inquiry and reflection creates experiential learning (Chan, 2012). Kolb explored the processes associated with the perception; concrete experiences, and conceptual components to devise experiential learning (Chan, 2012). Kolb viewed learning as a process of acquiring abstract concepts that can be applied to a variety of different situations (McLeod, 2017). He is known for the view that “learning is the process whereby knowledge is created through the transformation of experience” (Chan, 2012, p. 406; McLeod, 2017, p. 1). When the learner is actively performing and involved in experiences, they engage in a recurrent pattern of feeling, watching, thinking and doing (Chan, 2012; McLeod, 2017). New experiences causes information to be processed and transformed into one’s understanding and permits the continuous development of new concepts. Experiential learning involves four cyclical stages. The four stages are concrete experiences, reflective observations, abstract conceptualization and active experimentation (Chan, 2012; McLeod, 2017). Essentially, the process is when an individual runs into new experiences; reinterpretations need to occur. They consciously reflect on the discrepancies between the new experience and their understanding. The reflective practices give rise to new ideas and then they can apply these ideas in the future. The cyclical nature of this process allows learners to enter at any stage; however, once entered, they must progress through the cycle for learning to occur. Additionally, the processing and perception continuum depicts four learning styles: diverging, assimilating, converging and accommodating (McLeod, 2017). The way a learner approaches new tasks is impacted by the individual’s emotional responses; how they think, feel, watch and do (McLeod, 2017; Morris, 2020). Therefore the experiential cycle and learning styles gives students more autonomy as it is the

learner's responsibility to make certain decisions and creatively come up with solutions. The experiential learning cycle places the onus on the learner's choices; therefore empowering them to take initiative and stimulate intellectual growth and emotional engagement, as they go through each stage of the cycle (Morris, 2020). While every learner may learn differently and be at a different stage, educators can use the experiential learning cycle through various inquiry-based, problem-based or project-based STEM tasks. This can make the learning purposeful and meaningful for the learner (Hsu et al., 2017; Morris, 2020).

In order to support girls in making STEM learning more meaningful, it is important to also understand where learners are at developmentally. In general, when an individual is attempting to learn something new, there are constant changes that are occurring within the individual. Bearing that in mind, educators need to be mindful of the ways students learn and adjust as needed. Many researchers have conducted research to show that student learning is a dynamic and active process. This process occurs in two stages, assimilation and accommodation (Brandon, A. F., & All, A. C., 2010; Voon et al., 2020). In the assimilation stage, individuals are active agents in knowledge acquisition. Through the processing of information, the individual is constructs and reconstructs new meaning based on prior knowledge and experiences. This process develops new outlooks, and gets the individual to rethink and evaluate their current perceptions, which leads to intellectual growth (Bada, D., & Olusegun, S., 2015; Brandon, A. F., & All, A. C., 2010). In the accommodation stage, the incongruency in the individual's current understanding leads to changes where the individual modifies and transforms what they know to re-establish their equilibrium (Voon et al., 2020). Studies indicate that when an individual is faced with new learning situations, it disrupts their equilibrium as the new situation does not fit with their existing knowledge. In an attempt to restore the equilibrium, the individual raises their awareness and tries to reframe the experience in an attempt to restore the equilibrium. This is why STEM learning is crucial for girls during their adolescence. Adolescence is a milestone for an individual as they learn, grow, and develop (Ellis-Robinson, 2021; Kelly et al., 2020). Girls

should be provided with ample learning opportunities for STEM identity exploration during this time so that commitment is easier to achieve (Steinke, 2017).

Educators can make student learning more meaningful by learning about their students, their lived experiences and to teach through them. Research shows when cultural references, ideas and experiences of students are incorporated into the learning process, it encourages learners to explore the content material through their own personal lens (Hunter-Doniger et al., 2018). More and more educators are using this practice and culturally responsive approaches (Cummings et al., 2019) in their STEM classrooms for this reason, as it also has the ability to raise the interest and achievement of minority students (Cummings et al., 2019; McClain & Colina, 2022). Culturally Responsive approaches provide historically minoritized students with more access to learning. A culturally responsive framework has the ability to infuses cultural awareness into a STEM classroom and is a direct way of engaging and meeting the diverse needs of the learners (McClain & Colina, 2022). Researchers found that through culturally responsive practices, students report an increase in the value and connection to course content, better understanding, and development of critical thinking (Cummings et al., 2019) because it is relevant to them. One example of a culturally responsive approach is hip-hop pedagogy. Hip-hop Pedagogy is a culturally responsive resource as it uses hip-hop culture to supplement curriculum or instruction in the traditional classroom. The integration of hip-hop with course content is valuable as it can be leveraged to improve STEM performance and enhance an individual's STEM identity. Educators are using it more in classrooms as it is a culturally aware learning tool; students are able to make connections and re-envision content based on their lived experiences (Cummings et al., 2019). Studies have shown that STEM hip-hop pedagogy has the potential to increase interest, participation, acquisition of STEM knowledge and STEM identity in minority students (Cummings et al., 2019; McClain & Colina, 2022). Studies incorporating hip-hop provided learners with a cultural space that empowered them to understand and learn STEM-related information in a way that was relevant to them and their

academic abilities. They were able to re-envision what they had learned and incorporate it into their lived experiences (Cummings et al., 2019; Hunter-Doniger et al., 2018; McClain & Colina, 2022).

As a result, providing students with more innovative learning opportunities will allow for more meaningful learning. The research highlights that STEM experiences do not always need to be obtained from a lab. Within the research, scholars have linked early STEM experiences with identity development concerning STEM (Dou et al., 2019; Dou & Cian, 2021; Hachey et al., 2022; Speldewinde & Campbell, 2021). Researchers have stipulated that alternative environments in an individual's formative schooling years are conducive to developing STEM capital and, thereby, their STEM identity (Cohen et al., 2021; Hachey et al., 2022; Kelly et al., 2020; Ortiz et al., 2020; Speldewinde & Campbell, 2021). This confidence gained in these environments, in turn, motivates individuals to pursue STEM later on in their academic journeys. Below are some of the innovative ways of engaging historically marginalized students to gain more STEM experiences in alternative and experiential environments.

Chapter 5. Alternative Practices to Develop STEM Identity

STEM fields have a reputation for being hostile environments (Carlone & Johnson, 2007; Rodriguez et al., 2021). These fields are very competitive and, in attempts to be unbiased in the selection process, end up creating a culture-free environment (Solomon et al., 2022). By ignoring intersecting identities, the ethnicity and culture of individuals severely limit STEM access for youth (Hachey et al., 2022; Johnson et al., 2011; Solomon et al., 2022). Unfortunately, this has impacted marginalized individuals more as they are often underrepresented in STEM fields as their intersecting identities do not match the academic community norms they are trying to enter.

Many marginalized individuals in STEM fields have been reported to have undesirable identities, identities born out of racist and sexist stereotypes ascribed to them. An ascribed

identity is determined by others and is placed on an individual (Johnson et al., 2011). Marginalized individuals, especially women of colour, have a higher risk of being given an ascribed identity by being highly visible (Johnson et al., 2011). In Johnson (2011), the three women: Kathy, Alethia and Conchita, were restricted by the intersecting identities they possessed and experienced constraints in their pursuit of STEM. For example, Kathy, an indigenous female university student, experienced turmoil in her attempt to pursue a microbiology major. Her cultural and traditional views of her tribe were in conflict with one of the requirements of her microbiology major, completing a dissection. It was even more constraining for her as a pregnant woman. Dissection, in general, was not acceptable with her tribe; however, as a pregnant woman, it was worsened as they believed it would put her pregnancy in danger (Johnson et al., 2011). Many women, like the above example, have been placed in similar situations in STEM fields; they have to consistently avert and defend themselves against unwanted identities ascribed to them. Failure to recognize and respect cultural norms and values can cause internal conflict for marginalized individuals (Carlone & Johnson, 2007). The balancing act of aligning their social identities with the STEM identity they are trying to create while warding off any ascribed identities leads to feelings of discouragement and loneliness (Johnson et al., 2011). These competing identities are not sustainable for long; they are eventually are faced with the difficult choice of deemphasizing parts of their identities they value to stay in the STEM field or give up and seek an alternative environment.

Another factor detracting marginalized individuals from persisting in STEM fields is recognition or the lack thereof. In Johnson (2011) and Carlone and Johnson (2007), these researchers use Gee's term bids of recognition to talk about how identities are intentionally asserted. Therefore when an individual has been overlooked by meaningful people, mentors or professors in STEM fields or has failed to be recognized by them, this negative recognition impacts an individual's internal recognition process. Research shows that participants report increased feelings of disappointment and disconnect that dissuade the development of a STEM

identity (Carlone & Johnson, 2007; Diamond & Stebleton, 2019). The repeated failure to recognize and validate an individual's efforts is more likely to cause them to abandon their pursuit of STEM, resulting in a disrupted STEM identity (Carlone & Johnson, 2007; Exarhos, 2020; Johnson et al., 2011). It is for this reason determining ways to bridge the gap to retain marginalized individuals in STEM is essential; and alternative learning practices can be a solution.

Alternative STEM learning practices are an excellent opportunity to spark creativity and out-of-the-box thinking in students. These unconventional practices provide new and innovative ways of engaging students to learn new concepts or skills in STEM than the traditional learning methods. One study by Speldewinde and Campbell (2021) features the use of the bush environment in Australia to provide students with rich hands-on STEM learning. This alternative practice involves a nature, play-based approach to early childhood education that takes advantage of the environmental resources: foliage, grass, trees, bushes, soil and dirt. The various tactile surfaces and textures, provides different learning opportunities that foster engagement, curiosity and creativity. Students have abundant opportunities for discovery; any loose parts found in the environment can be manipulated and used to learn about STEM. For example, participants used the foliages as currency to practice counting in their play-based learning.

Another alternative practice are linked to early STEM identity development is Makerspace. Makerspace encourages students from a young age to experiment, be creative, problem-solve, observe and reflect, thereby enhancing their learning process and understanding. Makerspace is an effective way to provide students with learning-by-doing and project-based STEM learning experiences. These tasks allow individuals to tinker and use available resources to blend physical and digital technologies to enhance their design thinking, building and testing skills (Avendano-Uribe et al., 2022; Hachey et al., 2022). In one study by Avendano-Uribe and colleagues (2022), researchers found that bringing Makerspaces to rural

areas in Columbia created STEM communities of practice. Learners reported they were engaged in the learning because their tasks involved dealing with real-world problems, hands-on tinkering with STEM tools and using recycled materials like coconut fibres and seashells to create a new product. Reusing and repurposing materials to create something new was important to their community and culturally relevant. They found that Makerspace activities in rural communities were a source of innovation. It brings together the collaboration and resourcefulness of individuals, their confidence, skills and knowledge to creatively design and fabricate an artifact that would be relevant to their culture.

In a different Makerspace exploration by Hachey and colleagues (2022), a story was used as an anchor, and participants were tasked with the role of ensuring the safety of Jasper, the bunny, from the creepy carrots. Researchers found that participants were focused on their building and used the various loose materials to design and redesign their building to create meaningful artifacts. Results from the artifact creation revealed that all three groups, all girl, all boy and mix-gendered group incorporated animal creations in their final design. The same-gender groups had a tendency to display stereotypical characteristics in the design and discussion; however, the mixed-gendered group design included a variety of different ideas. This group discussed using lasers, cameras, cages, and nets on the inside and lava and tigers on the outside as protection.

These studies revealed that altering the learning practices to learning in the bush, or Makerspace, has the advantage of neutrality; it removes any traditional gender roles. In the bush, playing with nature resources are not gender-coded, allowing girls and boys to participate in various activities to learn and have positive experiences with STEM. Research shows that these alternative practices shifted the girls' mindsets; they were more enthusiastic and willing to explore and experiment with STEM.

These alternative learning practices are beneficial as they provide students with a good foundation of STEM practices like observation, measurement and experimentation while

deepening their comprehension of STEM-relevant knowledge. Research has shown that these activities can cultivate an early STEM identity and form more positive attitudes toward STEM while developing a sense of belonging (Avendano-Uribe et al., 2022; Hachey et al., 2022). Finally, through the open-ended design, and experiential play, Makerspace activities use a design-based approach that situates the individual as an agentic inventor and allows for meaningful STEM role-taking (Hachey et al., 2022).

Another alternative STEM practice is where technology plays a more prominent role in the learning environment. The technology used in the classroom can take different forms; however, there has been an increased focus on game-based learning. Researchers highlight the effectiveness of game-based learning for learners because students are having fun and learning without realizing they are learning (Yadav & Oyelere, 2021). Studies recognize that incorporating technology and games results in increased engagement, knowledge, critical thinking, skills development and enjoyment (Agbo et al., 2021; Bers et al., 2014; Hewett et al., 2020; Padirayon et al., 2019; Pesare et al., 2016; Yadav & Oyelere, 2021), and more meaningful learning.

Research indicates that the learner becomes actively involved when they assume the role of a player in game-based learning. By assuming the identity of the player, learners become invested in the outcome of the game. It is from the learner's decisions within the game that the player interacts with the environment (Agbo et al., 2021). The active role the learner assumes in the game gives the learner a sense of control which creates agency; it is their choices that dictate the outcome of the game (Brandon, A. F., & All, A. C., 2010; DeCoux Hampton, 2012; Gee, 2000; Gee, 2013). Game-based learning provides its learners with an alternative environment for them to be responsible for their own learning and to gain independence by attempting tasks and challenges by themselves without the fear of making mistakes (Agbo et al., 2021; Gee, 2013; Padirayon et al., 2019; Pesare et al., 2016; Yadav & Oyelere, 2021). This is because new challenges are slightly beyond the learner's current competencies and cycle of

expertise; they remain pleasantly frustrated and are willing to persevere and explore to get to more complex challenges (Gee, 2013). This is one of the key advantages of this alternative environment; it creates a safe space that encourages learners to take risks in attempting new tasks and challenges (Gee, 2013). Research shows that learners gain new knowledge, meaning and skills from facing new challenges (Baytak & Land, 2011; Kafai & Burke, 2015; Padirayon et al., 2019; Yadav & Oyelere, 2021). Another advantage is within the gameplay parameter, the concept or skill are ordered and organized in levels of difficulty; this customization within the games allows learners to attempt problems and experience success (Buffington & Rosengrant, 2020; Gee, 2000; Padirayon et al., 2019; Yadav & Oyelere, 2021).

Finally, gameplay is not the only focus of game-based learning research. Learning by design has gained more attention; research indicates that more cognitive demands are involved in the designing elements of game design (Baytak & Land, 2011; Kafai & Burke, 2015). Game design is a dynamic process that includes multiple cycles of planning, designing, testing, debugging, knowledge sharing and social interaction (Baytak & Land, 2011). When learners engage in design and building challenges, the learning is more meaningful because they are able to create personal connections to the new information. Learners become more motivated to engage in the design process to achieve the end goal once there is a personal connection to the design (Baytak & Land, 2011; Kafai & Burke, 2015). This type of learning, whether it be gameplay or game design, is student-centered, and the teacher's prompts or the game's feedback are able to monitor learning and motivate learners (Brandon & All, 2010; Pesare et al., 2016; Yadav & Oyelere, 2021). The above expanded upon the idea of alternative environments and how they can positively impact STEM learning. I shared a few examples of alternative learning environments and how they support learning. In the following sections I delve more deeply into two alternative environment learning alternatives, first dance, and then vlogs. While there are numerous possible alternative environments I could have explored, I chose dance and

vlogs because of my interest in technology and arts-based mediums that promote STEM learning.

Chapter 6. Dance

The inclusion of the arts in STEM is starting to get more attention. Science, Technology, Engineering, Art and Mathematics (STEAM) is the interdisciplinary education that occurs when the arts are integrated with STEM learning (Buono & Burnidge, 2022; Fattal & An, 2019; Lineberry et al., 2020; Payton, F. C., White & Mullins, 2017). Interdisciplinary projects involve the inclusion of the arts in STEM education. Research in this area is really in its infancy and researchers are beginning to explore the affordances and barriers of interdisciplinary projects that include the arts in STEM (Solomon et al., 2022). Research shows that interdisciplinary teaching and assessing practices afford learners equitable explorations that lead to a deeper understanding of both the arts and STEM concepts, making abstract concepts more concrete for learners to grasp (Fattal & An, 2019; Simpson Steele et al., 2016). Studies show that arts-integrated STEM lessons help students make connections between subjects and can influence the learners' perception of the STEM concept being learned (Deans, 2016; Shamir et al., 2019). Researchers have reported enhancements in creativity, teamwork, problem-solving and skill development in learners (Payton et al., 2017).

Dance has been used by educators as an educational tool. Dance has been shown to enhance the learning experience by improving academic performance and increasing student motivation Dance involves "physical, ideational, emotional, creative and cultural way(s) of knowing" (Solomon et al., 2022, p. 46). With dance, students benefit from three modalities of learning: auditory, visual and kinesthetic (Shamir et al., 2019; Solomon et al., 2022), creating a holistic learning experience. Dance environments afford students a safe space to develop creative, critical, innovative, problem-solving and abstract thinking skills that allow for authentic meaning-making (Deans, 2016; Lineberry et al., 2020; Shamir et al., 2019). Despite the number

of educational benefits of dance for learners, the use of dance in classrooms is still limited (Deans, 2016; Lineberry et al., 2020).

Despite the limited focus on dance in STEAM education, dance's impact is promising (Lineberry et al., 2020). Research indicates positive outcomes of engaging learners in abstract thinking, creativity and innovative thinking (Hachey et al., 2022; Johnson et al., 2011; Shamir et al., 2019; Solomon et al., 2022) from utilizing an art-based medium to support student learning in STEM fields. The dance element alters the learning environment and incorporates kinesthetic learning that enhances the experience and improves attitudes toward STEM learning (Hally & Sinha, 2018). The kinesthetic approach effectively improves cognition and memory. Participants must think about movements before doing them, requiring them to process information quickly (Fattal & An, 2019). Studies show that dance is able to provide learners with a safe and holistic learning experience and create a genuine learning community (e.g., Payton et al., 2017; Solomon et al., 2022). In these studies, individuals were able to use their creativity and imagination to connect non-STEM content with STEM content (Deans, 2016). At the same time, students interacting together led to active group learning, more collaboration and teamwork among the students (Deans, 2016; Fattal & An, 2019; Simpson Steele et al., 2016).

One of the foundational benefits of dance is that it increases classroom-based physical activity (Watson et al., 2017). Dance reinforces a pedagogical practice called movement integration. Movement integration is when physical activity is infused into academic lessons through being the physical visualization of what is being taught (Webster et al., 2019). A number of different movements and gestures occur in dance. Gestures involve the movement of hands, face and other body parts that are used as a way of communicating (Gerofsky, 2011). Both gestures and movement in dance have been deemed good for physical health by improving sensorimotor skills and strengthening physical, social and emotional interactions between people and the environment (Zaferiou, 2023). This is because dance is a whole-body movement practice that uses the body's center of mass. Dancing involves the mind-body interaction; the

nervous system controls the coordination of various limbs to cause a multisensory interaction with the environment (Zaferiou, 2023).

When individuals perform movement, they use their auditory and visual faculties to process the experience. They utilize and fortify multiple different neural pathways of the brain. Physical experiences involving gestures and movements utilize the auditory, visual and kinesthetic modalities of learning (Shamir et al., 2019) that create multimodal traces of neural activity and produce more significant neuronal resources long after the activity is over in comparison to singular modalities of learning like listening to a description or watching an activity (Gerofsky, 2010). Therefore, gestures also indicate an individual's understanding by being a source of information to alter their thinking or create new knowledge (Gerofsky, 2010). Analysis of gestures and how we use our bodies is gaining more attention as a way of uncovering unconscious components of thought that relate abstract concepts to their physical expression. Bodily movements in dance have a way of grounding the abstraction of the learned concept and checking for student understanding (Gerofsky, 2011). This mode of inquiry places the learner at the center because they are actively involved in their learning (Solomon et al., 2022).

Numerous studies have leveraged the elements of dance: body, energy, space and time as a metaphor to teach a wide array of STEM concepts (e.g., Buono & Burnidge, 2022; Fattal & An, 2019; Simpson Steele et al., 2016). One study was able to link dance movements and physics to increased learning and positive engagement in black girls using the periodic table (Solomon et al., 2022). Dance allowed the participants multiple ways of bodily knowing and meaning-making through the senses, muscles and perception. When the body and its movements in space and time aligns with the elemental idea of physics, which is the "study of matter, its motion and behaviour through space and time, and the energy and forces that impact it" (Solomon et al., 2022, p. 74-75). Aligning dance with the concept of physics allowed for a more comfortable entry point, which resulted in more positive associations among the female

participants. Dance was able to reframe the girls' preconceived negative notions of the periodic table. Through the movements of their bodies, they were able to enact the physical properties of the elements. They used their surrounding space to demonstrate the lightness of hydrogen with one electron and the heaviness of a densely packed elemental structure of iron. Their bodies became a physical learning tool of the periodic table, where they explored and engaged in discussions as they moved, collided and interacted with each other (Solomon et al., 2022).

In addition, dance-integrated projects for young girls can be an excellent opportunity for them to perform, create and build confidence in themselves but also in their knowledge of the STEM content (e.g., Hally & Sinha, 2018; Lineberry et al., 2020; Solomon et al., 2022). One example of this can be seen in a study on the Dance-A-Bit camp, a camp program that leveraged dance to teach and empower elementary girls with algorithmic design and thinking (Lineberry et al., 2020). This camp integrated the arts into a STEM-based lesson. Participants were tasked with creating a dance routine incorporating the basics of computer programming. Designing a dance routine assisted the participants in connecting specific movements to specific algorithmic functions such as if/then statements and loops. Therefore, the task of creating this dance routine allowed for experimentation and testing to debug their code to make sure the dance fits with the song (Lineberry et al., 2020). This type of arts-integrated STEM camp built the girls confidence in algorithmic thinking, and strengthened teamwork and problem-solving skills among the girls. Overall, the program gave the participants the opportunity to see how arts and STEM content do not have to be separate.

Therefore, the above research supports the notion that engaging in movement can increase students' focus, classroom on-task behaviour and academic performance when incorporated with curricular content (Watson et al., 2017; Webster et al., 2019). On that note, researchers have found valuable insight into student learning from merging dance and STEM curricular concepts. The value of dance and all that it affords to STEM learning can be seen in a number of studies (e.g., Buono & Burnidge, 2022; Deans, 2016, 2016; Fattal & An, 2019; Hally

& Sinha, 2018; Lineberry et al., 2020; Shamir et al., 2019; Simpson Steele et al., 2016; Solomon et al., 2022). For example, Fattal and An (2019) used two types of movements, stability, such movements include curling, balancing and stopping. The second type of movement was locomotor, such as sliding, galloping and leaping. These movements were performed at different spatial levels to depict the eight different transitory phases of the moon. Students could demonstrate their understanding of the moon phases by using the two types of movements and dance elements like different speeds, rhythms, combinations of movements and transitions (Fattal & An, 2019).

Another example is from Simpson and colleagues. In their study, they used dance to connect scientific concepts of wind, wind turbines and energy transformations. Students were able to use language and demonstrations with their bodies to describe and illustrate the four forms: gust, whirlwind, crosswind and zephyr (Simpson Steele et al., 2016). Using choreographic principles such as levels of space and floor patterns, students used improvisation to create movements to embody four forms of wind. Additionally, in groups, they used their bodies to create shapes and demonstrate how wind turbine blades catch different winds. Using movements and language helped students conceptualize and provide a better understanding of the scientific concept through an art form (Simpson Steele et al., 2016).

In another study, Buono and Burnidge (2022) demonstrated an increased scientific understanding of their participants through integrating dance and STEM learning. They did this through leveraging dance to learn about human microbes (Buono & Burnidge, 2022). Participants in this study were able to use their whole bodies to physicalize the scientific concepts of homeostasis and symbiosis. Through movement, they learned healthy “friendly” microbes help with digestion, strengthen the immune system and regulate mood, while “un-friendly” can cause diseases. Once participants understood the difference between the two, they were able to use their bodies to demonstrate and show a physical representation of a healthy microbe. The repeated action of falling and catching each other was used as a

metaphor of how healthy microbes interact and work symbiotically together to help stabilize our bodily systems. Through this activity, they understood they had to work together as a collaborative team in order to reflect a healthy microbe (Buono & Burnidge, 2022).

Shamir and colleagues (2019) used the integration of three forms of arts: dance, music and art animation to teach math and computer science concepts (Shamir et al., 2019). The students involved in the MathDance & Music model learned a dance adapted from Gerofsky (2013) called Mathdance. Through Mathdance students learned basic music theory, rhythms and the basic coding concepts like loops, conditional loops and variables to create a two-dimensional dance on Scratch. Once the basic coding tasks were complete, the study had a unique second phase where participants had to upload pictures of themselves in specific poses to create the dance animation on Scratch. Pre and post-assessments of students indicated MathDance& Music was an effective learning tool for students to learn math and computer science concepts.

Dance can be leveraged in STEM fields. As the aforementioned studies demonstrate, the integration of dance can lead to increases in academic performance, STEM understanding, and an increase in interest in STEM classes and careers. Dance provides learners with an alternative space for kinesthetic learning (Fattal & An, 2019; Hally & Sinha, 2018), leading to transformative embodied learning experiences (Payton et al., 2017; Steele et al., 2016). The thoughts produced when individuals use their bodies to create movements, the thoughts produced during these movements create is called embodied cognition (Deans, 2016; Solomon et al., 2022). Thoughts evoked during movement are influenced by the physiological processes involved in emotion and perception (Deans, 2016). Thereby suggesting a pivotal role for movements and gestures in shaping perception and interpretation of the information..

Emphasizing the value of embodied learning, research substantiates its efficacy in enhancing learners' comprehension and retention of content. By encompassing a multisensory and multimodal experience, embodied learning leverages different brain regions, providing

learners with a neurological advantage (Gerofsky, 2010). This firsthand engagement further facilitates swifter memory recall of sensorimotor experiences, contributing to a richer learning process.

Dance, as an embodiment of somatic, sensory, and intellectual elements, emerges as a potent tool for facilitating embodied learning (Buono & Burnidge, 2022; Gerofsky, 2010). Dance involves the interactive process of the mind, body, environment and the dynamic nature of engaging with the environment. Dance aligns with embodied theorists' views of learning, when individuals experience the world as situated, emotive and sentient (Gerofsky, 2010). Leveraging the body, dance movement, and gestures becomes an instrumental resource in fostering collaborative scientific learning (Solomon et al., 2022). It requires the individual to produce and communicate understanding by sensing, interpreting and translating visual, kinesthetic and auditory information that results in creative-expressive movements.

By deviating from traditional learning methods and environments and incorporating creative-expressive dance movements with STEM content, educators pave the way for embodied investigations. Research exemplifies how these alterations created a comfortable entry point and ameliorated the comprehension of abstract scientific concepts- ranging from microbes to the periodic table, algorithmic thinking, moon phases, and wind energy—making these abstract notions more tangible for learners to grasp (Buono & Burnidge, 2022; Fattal & An, 2019; Lineberry et al., 2020; Simpson Steele et al., 2016; Solomon et al., 2022).

This innovative practice in the learning process enables learners to not only conceptualize but also personalize these abstract concepts, forging connections between abstract knowledge and embodied understanding together (Gerofsky, 2010; Gerofsky, 2011). This holistic approach intersects the physical, mental, and emotional aspects together in the individual to create a memorable and comprehensive learning experience.

With these advantages in mind, dance can be a cultural, social and relational resource for individuals (Solomon et al., 2022). Dance not only permits STEM integration but cultural

integration as well. Studies have shown that an individual's funds of knowledge and lived experiences can be essential curricular tools. Funds of knowledge is defined as the accumulation of historical and cultural bodies of knowledge and skills that are important to the functioning and well-being of an individual and their families (McClain & Colina, 2022). By employing dance as an educational tool, cultural relevance is infused into the learning process as a byproduct, creating a cultural space (Solomon et al., 2022). Practices that support funds of knowledge are valuable because they acknowledge that learners do not come with a clean slate when they enter the classroom. Not every student is the same or has the same experiences. Hunter-Doniger (2018) used the "gingerbread cookie" as an analogy to explain how cultural differences impact student learning and participation. Hunter-Doniger explains that each gingerbread cutout might look the same, but when details are added, such as culture, socioeconomic status, geographic location and family backgrounds, the cookies take on a form all on their own. Therefore, the cookie-cutter teaching mentality does not work for a culturally diverse demographic (Hunter-Doniger et al., 2018). Dance, because it has the possibility to take into account previous experiences is a good pedagogical tool to support culturally diverse learners.

In Solomon (2022), the integration of dance to teach the properties of the periodic table to young black girls is an excellent example of supporting the learning of marginalized individuals. African-American individuals are often underrepresented in STEM (Cummings et al., 2019). The lack of inclusion and access to physics begins in middle school. Exclusion and access to physics began long before higher education. Therefore, researchers in this study used dance and the girls' prior knowledge of hip-hop to reframe and develop new relationships and associations with the periodic table. Hip-hop pedagogy has gained a lot of popularity as it is a dominant language among youth culture (Akom, 2009). It has been used as an adaptive teaching tool (Akom, 2009; Cummings et al., 2019; McClain & Colina, 2022) because of its multiple elements, such as break dancing, deejaying, graffiti art, fashion and emceeing. Hip-hop

has expanded with time but its history and origins can be traced back to Africa (Akom, 2009), which makes it rich in funds of knowledge for learners to bring their cultural knowledge and movements into the learning space. Participants in Solomon and colleague's (2002) study were able to use their knowledge of krumping involving strong, direct movements of the arms and shoulders while stepping, rhythmic stamping and body clapping to show their understanding of the weight and density of iron. In the dance space the researchers created, funds of knowledge and lived experiences were invited and welcomed. By honouring and empowering the girls to use their lived experiences to influence thinking and decision-making, the girls were able to use their personal cultural knowledge. When these girls were able to use krumping and stepping, they were able to see a representation of their cultural world in the realm of physics.

A dance learning environment invites its learners to bring their culture, their beliefs, values and esthetics surrounding dance into their space (Solomon et al., 2022). Dance is a common element of expression, unifying different cultures and bringing people together. Through the mode of dance, individuals can feel empowered to express themselves and share their dance and community traditions (Cummings et al., 2019; McClain & Colina, 2022; Solomon et al., 2022). What is unique about dance is that it lies at the intersection of the individual lived experiences and the dance experience. This type of engagement creates a relationship between the individual's funds of knowledge, as well as their social, cultural, historical, political and physical way of knowing to make sense of the situation (Esteban-Guitart & Moll, 2014; Solomon et al., 2022). Dance is a powerful tool that supports educators in harnessing students' funds of knowledge and lived experiences and bringing them into the classroom. Dance can be used as a method to bridge the gap between school and home. When educators account for students' funds of knowledge in academic settings and consciously attempt to integrate it into instructional practices and activities, it has the potential to improve student performance in minoritized students. Dance creates trust between teachers, students and their families,

empowers students and honours their families lived experiences (Hachey et al., 2022; McClain & Colina, 2022).

Chapter 7. Vlog

Technology is constantly evolving and has become a fixed part of our lives. Research shows that technological tools like tablets and smartphones, makes the integration of STEM content more accessible for teachers. These tools also make it easier for teachers to incorporate 21st-century skills (Bers et al., 2014; Ismail et al., 2019). Of the many tools, videos, have become a popular educational resource for teachers to use to enhance motivation and promote student success. In STEM contexts, videos can be used to achieve better conceptual understanding of course content, mastery of complex problem-solving and improve laboratory preparedness (Campbell et al., 2022; Seethaler et al., 2020). STEM learning videos can be instructional if designed strategically. This means taking into account the content and sequencing, cognitive supports, and affective considerations are taken into account (Seethaler et al., 2020). STEM instructional videos can clarify concepts by making links to students' knowledge and building on students' knowledge without any misconceptions or gaps. Often, videos can provide the viewer with an opportunity for STEM problem-solving. For example, by providing a short story, a problem or a puzzle that needs to be resolved by the end of the video. Embedded within the video can be graphics, animations, visual cues and verbal guidance. These cognitive and visual supports help clarify concepts (Seethaler et al., 2020). As a result, learning videos have been shown to be a more useful and effective multimedia tool in the learning process in comparison to other tech teaching tools like PowerPoint media slides. Learning videos can increase student understanding and student interest in the learning process and the achievement of their goals (Ismail et al., 2019; Susanti et al., 2021). The interactiveness of STEM videos is a new and affordable means of engaging and providing

learners with active, guided learning of complex concepts such as microscopic, submicroscopic and astronomical structures by facilitating science visualization (Ismail et al., 2019; Seethaler et al., 2020).

The technology used in the classroom can take different forms; however, the continuous growth and development of social applications have allowed STEM learning to be filtered into social media blogs, Facebook, Twitter, TikTok, virtual reality (VR), and augmented reality (AR), and most notably YouTube. STEM content has been integrated into these social applications as a teaching and learning method to engage and motivate learners (Gil-Quintana et al., 2020). Studies have found that YouTube as an educational tool (Campbell et al., 2022; Gil-Quintana et al., 2020; Otchie et al., 2020), allows for deeper understanding because of the ability to pause, explain and reflect throughout the video. YouTube videos are designed similar to instructional videos; however social media etiquette determines the video selection by learners, even for STEM videos. Learners are able to make quick video selection decisions by time length, previous view count and video recommendations in the YouTube world (Kleinberg et al., 2018). YouTube, with its two billion active users, serves as a platform for storing and showcasing a multitude of STEM video content. It has also been used as a critical tool for the learning process and the acquisition of STEM competencies (Gil-Quintana et al., 2020). YouTube STEM videos are an excellent tool to complement hands-on scientific experiments and can be used to supplement science lessons (Otchie et al., 2020). Having free access to YouTube's STEM videos bridges the gap between theory and practice for learners, especially those in underprivileged schools. Access to these free resources allows for scientific experiment lessons and real-world connections and serves as a way to inspire and motivate learners worldwide . (Otchie et al., 2020).

Previous studies have demonstrated the value and effectiveness of instructors authoring videos for learners to view. At the same time, there is a growing focus among researchers to assess the effectiveness of student-created videos (Campbell et al., 2022). The process of

creating videos themselves, instead of watching already created videos, may be a more meaningful and authentic form of learning for learners. Learning pedagogies that embed technology and learning together are more student-centered. Students become active participants in their own learning. In this way the responsibility shifts to the student to seek, synthesize information, and reflect and organize the content to produce a video (Campbell et al., 2022). The video creation process requires active participation and involvement of the learners. Research (e.g., Campbell et al., 2022; Laila et al., 2022; Lawrie & Bartle, 2013; Xie et al., 2021) shows learners engaging in this video-creation process result in a deeper understanding of the related concepts being learned, development of digital literacy and a positive impact on student engagement.

A popular video format found on social media platforms like YouTube is called video logging. A video log (vlog) is an online visual multimedia tool for individuals to talk directly to the camera. Individuals utilize a camera to interact with their audience (Cummings et al., 2020; Farrukh et al., 2021; Frobenius, 2011; Kleinberg et al., 2018). Vloggers on social media produce and share their ideas on various topics that are important to them in a scripted and unscripted monologue style (Cummings et al., 2020; Frobenius, 2011). Vloggers use their platform to create vlogs for different purposes: advice sharing or seeking, result sharing or storytelling (Huh et al., 2014; Phelps-Ward & Laura, 2016). The intent of their vlog is so that it can be of service to increase knowledge and build community by inspiring, educating, motivating and encouraging their viewers (Huh et al., 2014; Raby et al., 2018). Vlogging has found its way into educational settings as a form of student-created videos (Kleinberg et al., 2018).

To create a successful vlog, individuals engage in content and video creation. Creating vlogs a lengthy process where individuals must be knowledgeable and passionate about the topics or issues they are addressing. They have to consider the verbal and nonverbal characteristics when communicating, ensuring that they are talking at the right speed and making eye contact. In addition,determining how the videos are edited and considering the

video aesthetics is important to the creation process (Kleinberg et al., 2018). Numerous decisions must be made in the editing process, such as camera positioning, whether to use a backdrop, lighting options, or adding music and transitions. All of these little components significantly impact audience engagement in the final product (Raby et al., 2018). From the research collected, video logging is seen as an impactful learning resource for diverse environments. It is beneficial for both the individuals creating and individuals who view the vlogs. When individuals share their thoughts, they are expressing their understanding and they practice reflective thinking, which is informative for those who observe the vlogs (Batchelor & Cassidy, 2019; Campbell et al., 2022; Farrukh et al., 2021; Gurjar, 2022; Huh et al., 2014; Laila et al., 2022; Lawrie & Bartle, 2013; Maj, 2018; Phelps-Ward & Laura, 2016; Sharpe et al., 2022; Xie et al., 2021).

There were very few research articles that looked at STEM and video logging in my research. What is interesting to note is there could be a potential for video logging to be educative in the STEM field. It is my recommendation that more focus and studies be conducted in this area because from the small sample of studies I gathered, video logging has been used in a variety of different environments that served an educative purpose. In the healthcare sector, health vlogs have been used as a means to support patient education to improve patient information literacy (Huh et al., 2014; Maj, 2018). The most common form is healthy living vlogs focused on diet and fitness. These vlogs serve as a resource to introduce changes in eating and exercise habits to become healthier. Vloggers are able to share their own experiences and use their own bodies as representation to give advice to motivate their viewers (Maj, 2018). Health vlogs were also used as a social support in patient education for chronic illness management such as HIV, diabetes and cancer (Huh et al., 2014). Researchers found vlogs to have a positive impact, both informationally and emotionally on patients. The videos provided an enriched and intense exchange of personal information; They shared personal experiences, past diagnoses, hospital visits, their struggles with dealing with pain and staying emotionally strong, updates on

treatment and future treatment plans. These vlogs are created with the same principles, using eye content, pauses and facial expressions; but the relationship between the vlogger and viewers has been described as an intensely personal connection. These health vlogs were able to capture in-the-moment experiences and by sharing these experiences, vloggers and those viewing them were able to give and receive social support (Huh et al., 2014). The vlogger and viewers developed a strong personal connection to the content as they were going through the same diseases and had bonded over similar experiences and struggles. Due to the relatability of the content, viewers engaged with the vlogs and commented, sharing their own experiences and offering hope. Even viewers with different diseases acknowledged similar emotional experiences, thereby creating a strong empathic community and support system.

Additionally, researchers used vlogs to engage individuals experiencing special education needs in a unique participatory research project. Participants got the opportunity to be in an inclusive environment where they were able to engage in various adapted sporting formats (Sharpe et al., 2022). Participants were to create vlogs, recording their sporting experiences throughout the day, and commenting on anything they found interesting, important or unique about the experience. Researchers found two notable findings from the participant's vlog creation. First, creating vlogs was an empowering learning experience; each participant was the star, producer, director and editor of their vlog (Sharpe et al., 2022). The practical and creative learning opportunity of creating vlogs gave participants full control and input over the creative process, content and editing of the vlog. Second, researchers also found when participants shared their experiences and perspectives; many shared how much they valued the inclusive sports framework and felt a sense of belonging in a sports environment. The vlogs were also informative for stakeholders on how to make sports more inclusive for individuals experiencing special education needs in the future. This project's unique participatory nature of adapted sports and vlogs allowed individuals experiencing special education needs to have meaningful experiences and feel successful in sports.

Another area of research regarding vlogs is in literacy engagement, especially for English language learners (ELL) (Batchelor & Cassidy, 2019; Gurjar, 2022; Xie et al., 2021). Research shows vlogs can have a positive effect on enhancing a learner's listening, writing and speaking skills by improving fluency, accuracy and accent but also alleviate some of the anxiety and anxiousness associated form learning a new language (Xie et al., 2021). The multimodal aspects of a vlog, the text, images, sound, music, and gestures provide flexible support to the individual's learning process. The process of composing and producing a vlog has shown benefits to the learners' learning performance and language skills.

In one study on literacy engagement, a vlogging activity was seen as an interesting and novel experience to complete a writing task. The use of technology with the multimodal aspects of vlogs altered the traditional environment and the expectations of writing tasks. Participants were more eager and interested to participate in the vlog process which resulted in improved writing proficiencies (Xie et al., 2021). Another study on literacy used Flip, a free video-logging learning tool, to promote literacy engagement and 21st-century digital literacy skills in elementary school (Batchelor & Cassidy, 2019; Gurjar, 2022). Flip is a web-based and a mobile-accessible digital video recording platform with audio, video and text features. Researchers in this study used Flip as an online collaborative video discussion tool. In this study, after participants first created book talk vlogs and posted them in a shared forum, they then responded with feedback to book talk vlogs created by their peers (Batchelor & Cassidy, 2019). Participants used the criteria of a successful book vlog: energy, summary, passage, connections, flow and time (Batchelor & Cassidy, 2019) to provide feedback to other participants. The book talks were a way to encourage classroom conversations and higher-level questioning in students. Creating and responding to each other's book talk vlogs was an excellent way to produce digital content, utilize an online environment to digitally dialogue among classmates, and foster curiosity in different book genres. Participants engaged in

reading, making and sharing connections they made with the text and hearing critical feedback that can be used for any future book talk vlogs.

Flip was also used in another study, however, in this study FLIP served a different purpose. Researchers used the social networking aspects of Flip to build a classroom community and to create an inclusive, global collaborative space. Flip's Grid Pals feature was used to allow participants to collaborate with students from classes from around the world on a Clean Water and Climate Change project (Gurjar, 2022). Participants were excited about this initiative. Participants were proactive in research and gathered information to share with their collaborators in Kenya on the project. The active involvement of participants enhanced literacy skills, as well as digital literacy skills through their engagement in reading, writing, speaking, listening, checking the accuracy of sources, and learning etiquette of the digital platform (Gurjar, 2022).

In terms of STEM education, the field of research on vlogs is narrow and somewhat underexplored. The studies I have found show the benefits of volgs for enhancing understanding and STEM learning (Campbell et al., 2022; Laila et al., 2022; Lawrie & Bartle, 2013). Researchers from two studies were able to integrate vlog creation to support the acquisition of chemistry literacy and enhance understanding of hydrocarbons and the structure representations and properties of molecules (Laila et al., 2022; Lawrie & Bartle, 2013). The vlog creation task strengthened participants' understanding through their research into information for the structure-property relationship and the correct use of vocabulary and terminology in their explanation (Lawrie & Bartle, 2013). Participants reported the process of researching and reviewing the information to create the vlogs was valuable. This task was an active form of learning that led to a deeper understanding (Laila et al., 2022; Lawrie & Bartle, 2013)

Another study utilized student-created videos in an engineering setting for exam review (Campbell et al., 2022). Here too, researchers reported findings that participants found the process of consulting notes, class and online resources to summarizing course content in their

own words to create their vlog beneficial for their understanding in preparing for exams. The vlog creation process not only increased engineering knowledge, but participants reported increased confidence in the concepts from their descriptions in the vlogs (Campbell et al., 2022). In follow-up interviews, participants reported vlog creation as a more meaningful task as opposed to writing a paper or taking a quiz. Many participants reported they were engaged, inspired and found the vlogging task to be a form of self-expression (Campbell et al., 2022). The integration of vlogs in these two STEM disciplines provided students with a cross-curricular experience. Participants were enhancing their STEM knowledge while simultaneously learning the process of creating a vlog.

Vlogging is a concept that most students are familiar with and relevant to them because of social media. They already have an idea of what makes a good vlog and how to get high view and like counts through easily accessible social media platforms like YouTube, Vimeo, TikTok, Instagram or Snapchat (Cummings et al., 2020). It is for this reason that video logging is such a valuable educational resource and as demonstrated, has been used in a variety of different disciplines as a student-centered educational tool. Video logging is effective in educational settings because the learners become agentic choice-makers (Raby et al., 2018). The video creation process empowers individuals through a symbolic transfer of power from the teacher to the student (Sharpe et al., 2022). The individual reviews the material to create the content, determine the outline, and produce and share the ideas. In addition to content creation, numerous video editing strategies are involved in keeping their audience interested. Utilizing verbal and nonverbal cues, like working on their composure and delivery, their tones, and their facial and body language (Raby et al., 2018). It is for this reason that individuals find video logging tasks impactful; the decisions that go into creating the final video product strengthens their understanding of the concepts being learned.

In addition, video logging tasks provide learners with an alternative to formal schooling environment for learning and reflection to occur. The digital nature of the task allows for mobile

access, which gives students flexibility but also provides security. This means that the vlogs can be created and edited at home or school. Additionally, if the privacy settings on the digital platform are kept private, it alleviates any additional pressure to perform for learners (Gurjar, 2022), thus providing learners with an opportunity to be open and honest.

Another educational benefit of vlogging is that it gives every individual a voice. Creating a vlog requires the individual to review and analyze the content to share their findings and perspectives; this process indirectly encourages and supports reflection. In Boud (2001), reflection was defined as gathering unprocessed information, raw material and engaging with it to make sense of what has occurred. Boud views reflection as a way to turn experiences into learning by exploring and analyzing the experiences to learn new things. Through reflective practices, individuals derive meaning and can be meaning-makers from their experiences (Morris, 2020). In the continuous process of reflective observations, individuals come to new conclusions from their experiences (Wain, 2017).

The two most common approaches, reflection-in-action and reflection-on-action, to reflective practice used in education were developed by Donald Schon (Boud, 2001; Wain, 2017). Reflection-in-action describes the thoughts and actions that occur while the individual is trying to attempt something. In this type of reflection, learners have to use their knowledge or skill to make decisions ‘on the spot’ during experiences. The second, reflection-on-action, involves the process of thinking and looking back on an experience to see how it can affect future practice or future experiences (Wain, 2017). Students experience both types of reflection while creating their vlogs. However, having the flexibility to create and edit the vlogs at home permits further reflection. Once pressure has subsided on acting and reacting on the spot, further reflection and learning can occur (Boud, 2001). Reflection can be enhanced or inhibited depending on the positive or negative emotions the experience elicits and can provide more information within the context of the individual’s lived experience. Vlogs are therefore a great way of promoting reflective practice in the digital age.

The above-mentioned benefits of student-created vlogs could be advantageous to marginalized individuals in education. Although limited, there is a study that shows vlogs have been able to bolster the identity development of minoritized individuals through self-talk and self-expression (Cummings et al., 2020; Phelps-Ward & Laura, 2016). Vlogs were able to empower young black girls by creating a safe cyberspace to discuss hair care routines, tutorials and, by extension, explore racial identity (Phelps-Ward & Laura, 2016). By engaging in self-talk, results indicate participants experienced increased confidence, positive mood, self-esteem, self-regulatory functions and a sense of belonging. The subjective experience of inner dialogue reinforced their belief in themselves, supporting identity development (Phelps-Ward & Laura, 2016). While the interactions between the vlogger and viewers created a community of practice and a place for self-love among many young black girls. Although promising, more research is needed to confirm the positive effects vlogs can have on marginalized individuals in various educational environments like dance and STEM. Both mediums, dance and vlogs have been shown to have the ability provide new learning experiences for individuals when introduced separately; it would be interesting to determine the effects on learning and STEM identity if the mediums were combined.

Chapter 8. Conclusion

The competitive nature of STEM fields has often resulted in the underrepresentation of marginalized women. Compared to this, there is a possibility in new pedagogies to support all learners in STEM. STEM learning pedagogies have evolved so that STEM learning does not need to be restricted to traditional teacher-centred approaches. Alternative practices and technology are creating opportunities to provide students with new innovative pathways for STEM access and learning. These alternative pedagogies are beneficial not only for making the learning experience meaningful for its students, but also for also providing learners with a good

foundation of STEM practices like observation, measurement and experimentation–all this while still deepening comprehension of STEM-relevant knowledge (Hachey et al., 2022).

The initial focus of this paper was to determine a creative way of supporting historically marginalized girls' learning in STEM education. However, through my research, it was clearly evident that to support STEM education for girls, it was necessary to foster STEM identity development at the elementary school level. Research supports that the more positive STEM experiences girls accumulate, the more likely they feel a sense of belonging and be able to see themselves as STEM people. In turn, this sense of belonging can motivate them to pursue STEM ventures in higher education (Carlone & Johnson, 2007; Hachey et al., 2022).

In my paper, I explored STEM learning from two mediums: dance and video logging (vlog), and its impact on STEM identity and STEM learning. My literature review supports that infusing STEM learning into a dance environment creates a new way of providing positive and meaningful STEM experiences. Dance was purposeful and meaningful to learners as they were able to make interdisciplinary connections (Buono & Burnidge, 2022; Fattal & An, 2019; Lineberry et al., 2020; Payton et al., 2017). Many participants reported enjoying the kinesthetic nature of the gestures and movement in the interdisciplinary STEM projects as it provided them with a transformative embodied learning experience (Payton et al., 2017; Simpson Steele et al., 2016). Participants reported that engagement in these projects influenced their perception and attitudes toward various STEM concepts being learned (Buono & Burnidge, 2022; Fattal & An, 2019; Solomon et al., 2022) and improved their academic performance by helping them achieve a deeper understanding of the STEM concepts (Fattal & An, 2019; Simpson Steele et al., 2016). Altering the STEM learning environment to include dance was advantageous as it interweaved physical, mental, and emotional aspects together to create a memorable and comprehensive learning experience for its learners.

Moreover, these interdisciplinary projects can be a cultural resource for learners. Integrating particular dance forms known to students, like hip-hop, can help them reframe the

learning environment (Solomon et al., 2022). This reframing invites learners to bring in their prior cultural knowledge into the learning space. This was demonstrated in the research, for example, when girls used their prior knowledge of krumping and stepping to represent the properties of elements in the periodic table (Solomon et al., 2022). In spaces like these, individuals felt empowered to express themselves about the STEM concepts being learned but also felt safe to share their dance and community traditions (Cummings et al., 2019; McClain & Colina, 2022; Solomon et al., 2022).

Video log (vlog), is also a powerful tool. Vlogs, have served as an educational tool for learners in a variety of different learning environments (Huh et al., 2014; McClain & Colina, 2022; Lawrie & Bartle, 2013; Maj, 2018; Sharpe et al., 2022) and has empowered learners in multiple ways. While watching video logs was informative for learners, research has shown that there are a lot more educational benefits to student-created vlogs. For example, in one of the studies (Laila et al., 2022; Lawrie & Bartle, 2013), participants reported increased knowledge and confidence in the STEM concept being learned. Although the process of making a vlog may seem long and arduous, many participants reported enjoying the creative nature of the process. They were inspired and found the process valuable because of the active role they had in the process, leading to a deeper understanding of the concepts under study. The process of creating a vlog is favourable as it engages learners in the practice of reflection (Boud, 2001; Wain, 2017). The process of reviewing and processing information helps learners derive meaning and a connection to the content.

My research revealed that while vlogs are a good educational tool in a variety of areas, the use of student-created vlogs was limited in the STEM fields (Laila et al., 2022; Lawrie & Bartle, 2013). Through this synthesis, I learned that vlogs and their impact on STEM identity is underexplored. More research is needed to explore the effects of vlogging on STEM identity, particularly whether it can bolster the STEM identity of historically marginalized girls. Another area for future research is determining the impact on STEM identity, there effects on STEM

learning if both the mediums of dance and vlogging were combined in one unit. Is there a connection between dance vlogs and STEM Identity and STEM learning? Finally, I set out on this project because I wanted to learn about useful teaching tools that would support my students in their STEM learning. It is my hope that what I have learned will be useful for others as well. The synthesis of research in this paper presents a valuable resource for teachers as they decide whether to use dance and in their own STEM teaching.

References

Agbo, F. J., Oyelere, S. S., Suhonen, J., & Laine, T. H. (2021). Co-design of mini-games for learning computational thinking in an online environment. *Education and Information Technologies*, *26*(5), 5815–5849. https://doi.org/10.1007/s10639-021-10515-1

Akom, A. A. (2009). Critical Hip-hop pedagogy as a form of liberatory praxis. *Equity & Excellence in Education*, *42*(1), 52–66. https://doi.org/10.1080/10665680802612519

Avendano-Uribe, B. E., Ojeda-Ramírez, S., & Perez-Baron, J. (2022). Resourcefulness, narratives, and identity in science, technology, engineering, arts and mathematics education: A perspective of makerspaces for rural communities in Colombia. *Frontiers in Education (Lausanne)*, *7*. https://doi.org/10.3389/feduc.2022.1055722

Bada, D., & Olusegun, S. (2015). *Constructivism learning theory: A paradigm for teaching and learning*. *5*(6), 66–70.

Batchelor, K. E., & Cassidy, R. (2019). The lost art of the book talk: What students want. *The Reading Teacher*, *73*(2), 230–234. https://doi.org/10.1002/trtr.1817

Baytak, A., & Land, S. M. (2011). An investigation of the artifacts and process of constructing computers games about environmental science in a fifth-grade classroom. *Educational Technology Research and Development*, *59*(6), 765–782. https://doi.org/10.1007/s11423-010-9184-z

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, *72*, 145–157. https://doi.org/10.1016/j.compedu.2013.10.020

Boud, D. (2001). Using journal writing to enhance reflective practice. *New Directions for Adult and Continuing Education*, *2001*(90), 9–18. https://doi.org/10.1002/ace.16

Brandon, A. F., & All, A. C. (2010). *Constructivism theory analysis and application to curricula*. *31*(2), 89–92.

Buffington, L., & Rosengrant, D. (2020). Making differentiation magic in the classroom with minecraft. *The Physics Teacher*, *58*(8), 564–568. https://doi.org/10.1119/10.0002378

Buono, A., & Burnidge, A. (2022). Dancing our microbiome at the science museum: A dance/STEAM collaboration. *Journal of Dance Education*, *22*(2), 98–107. https://doi.org/10.1080/15290824.2020.1790568

Campbell, L. O., Heller, S., & Pulse, L. (2022). Student-created video: An active learning approach in online environments. *Interactive Learning Environments*, *30*(6), 1145–1154. https://doi.org/10.1080/10494820.2020.1711777

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Castro, E. L. (2014). “Underprepared” and “At-Risk”: Disrupting deficit discourses in undergraduate STEM recruitment and retention programming. *Journal of Student Affairs Research and Practice*, *51*(4), 407–419. https://doi.org/10.1515/jsarp-2014-0041

Chan, C. K. Y. (2012). Exploring an experiential learning project through Kolb’s learning theory using a qualitative research method. *European Journal of Engineering Education*, *37*(4), 405–415. https://doi.org/10.1080/03043797.2012.706596

Cohen, S. M., Hazari, Z., Mahadeo, J., Sonnert, G., & Sadler, P. M. (2021). Examining the effect of early STEM experiences as a form of STEM capital and identity capital on STEM identity: A gender study. *Science Education*, *105*(6), 1126–1150. https://doi.org/10.1002/sce.21670

Crenshaw, K. (2015, September 24). Why intersectionality can't wait. *Washingtonpost.com*. https://link-gale-com.uproxy.library.dc-uoit.ca/apps/doc/A429716314/AONE?u=ko_acd_uoo&sid=bookmark-AONE&xid=55cd995c

Cummings, R., Chambers, B., Reid, A., & Gosha, K. (2019). STEM hip-hop pedagogy: A meta-synthesis on hip-hop pedagogy STEM interventions tools for underrepresented

minorities in K-12 education. *Proceedings of the 2019 ACM Southeast Conference*, 46–52. https://doi.org/10.1145/3299815.3314431

Cummings, R. T., Huff, E. H., Mack, N. A., Womack, K., Reid, A., Ghoram, B., Gosha, K., & Gilbert, J. E. (2020). An exploration of black students interacting with computing college and career readiness vlog commentary social media influencers. *Computing in Science & Engineering*, *22*(5), 29–40. https://doi.org/10.1109/MCSE.2020.3005635

Deans, J. (2016). Thinking, feeling and relating: Young children learning through dance. *Australasian Journal of Early Childhood*, *41*(3), 46–57. https://doi.org/10.1177/183693911604100307

DeCoux Hampton, M. (2012). Constructivism applied to psychiatric-mental health nursing: An alternative to supplement traditional clinical education: CONSTRUCTIVISM IN CLINICAL EDUCATION. *International Journal of Mental Health Nursing*, *21*(1), 60–68. https://doi.org/10.1111/j.1447-0349.2011.00755.x

Diamond, K. K., & Stebleton, M. J. (2019). The science identity experiences of undergraduate, foreign-born immigrant women in STEM at U.S. institutions. *Journal of Women and Gender in Higher Education*, *12*(2), 143–165. https://doi.org/10.1080/19407882.2019.1568265

Dou, R., & Cian, H. (2021). The relevance of childhood science talk as a proxy for college students' STEM identity at a hispanic serving institution. *Research in Science Education*, *51*(4), 1093–1105. https://doi.org/10.1007/s11165-020-09928-8

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10.1002/sce.21499

Ellis-Robinson, T. (2021). Identity development and intersections of disability, race, and STEM: Illuminating perspectives on equity. *Cultural Studies of Science Education*, *16*(4), 1149–1162. https://doi.org/10.1007/s11422-020-10011-x

Esteban-Guitart, M., & Moll, L. C. (2014). Lived experience, funds of identity and education. *Culture & Psychology*, *20*(1), 70–81. https://doi.org/10.1177/1354067X13515940

Exarhos, S. (2020). Anti-deficit framing of sociological physics education research. *The Physics Teacher*, *58*(7), 461–464. https://doi.org/10.1119/10.0002061

Farrukh, F., Haidar, S., & Shehzad, W. (2021). Digital media and identity construction: Exploring the discourse of Pakistani vloggers. *Studies in Ethnicity and Nationalism*, *21*(2), 126–140. https://doi.org/10.1111/sena.12344

Fattal, L., & An, H. (2019). STEAM: Choreographing the phases of the moon. *Journal of Dance Education*, *19*(4), 178–182. https://doi.org/10.1080/15290824.2019.1664745

Frobenius, M. (2011). Beginning a monologue: The opening sequence of video blogs. *Journal of Pragmatics*, *43*(3), 814–827. https://doi.org/10.1016/j.pragma.2010.09.018

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, *25*, 99. https://doi.org/10.2307/1167322

Gee, J. P. (2013). *Good Video Games and Good Learning*. https://www.peterlang.com/document/1054442

Gerofsky, S. (2010). Mathematical learning and gesture: Character viewpoint and observer viewpoint in students' gestured graphs of functions. *Gesture*, *10*(2–3), 321–343. https://doi.org/10.1075/gest.10.2-3.10ger

Gerofsky, Susan. (2011). *Ancestral genres of mathematical graphs*. *31*(1), 14–19.

Gil-Quintana, J., Malvasi, V., Castillo-Abdul, B., & Romero-Rodríguez, L. M. (2020). Learning leaders: Teachers or youtubers? Participatory culture and STEM competencies in Italian secondary school students. *Sustainability*, *12*(18), 7466. https://doi.org/10.3390/su12187466

Gurjar, N. (2022). Connecting elementary students through grid pals to develop literacy skills. *The Reading Teacher*, *75*(5), 655–660. https://doi.org/10.1002/trtr.2083

Hachey, A. C., An, S. A., & Golding, D. E. (2022). Nurturing kindergarteners' Early STEM

academic identity through makerspace pedagogy. *Early Childhood Education Journal*, *50*(3), 469–479. https://doi.org/10.1007/s10643-021-01154-9

Hally, T., & Sinha, K. (2018). SHINE for girls: Innovating STEM curriculum with dance. *Childhood Education*, *94*(2), 43–46. https://doi.org/10.1080/00094056.2018.1451689

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, n/a-n/a. https://doi.org/10.1002/tea.20363

Hewett, K. J. E., Zeng, G., & Pletcher, B. C. (2020). The acquisition of 21 st century skills through video games: *Minecraft* design process models and their web of class roles. *Simulation & Gaming*, *51*(3), 336–364. https://doi.org/10.1177/1046878120904976

Hsu, Y.-C., Baldwin, S., & Ching, Y.-H. (2017). Learning through making and maker education. *TechTrends*, *61*(6), 589–594. https://doi.org/10.1007/s11528-017-0172-6

Huh, J., Liu, L. S., Neogi, T., Inkpen, K., & Pratt, W. (2014). Health vlogs as social support for chronic illness management. *ACM Transactions on Computer-Human Interaction*, *21*(4), 1–31. https://doi.org/10.1145/2630067

Hunter-Doniger, T., Howard, C., Harris, R., & Hall, C. (2018). STEAM through culturally relevant teaching and storytelling. *Art Education*, *71*(1), 46–51. https://doi.org/10.1080/00043125.2018.1389593

Ismail, M. Z., Mansor, A., N., Iksan, Z., & Mamad, N. (2019). The impact of using stem video in teaching on students' learning engagement in Malaysia. *International Journal of Recent Technology and Engineering (IJRTE)*, 1-8.

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching*, *48*(4), 339–366. https://doi.org/10.1002/tea.20411

Kafai, Y. B., & Burke, Q. (2015). Constructionist gaming: Understanding the benefits of making games for learning. *Educational Psychologist*, *50*(4), 313–334. https://doi.org/10.1080/00461520.2015.1124022

Kang, H., Calabrese Barton, A., Tan, E., Simpkins, S., Rhee, H., & Turner, C. (2019). How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education*, *103*(2), 418–439. https://doi.org/10.1002/sce.21492

Kelly, R., Garr, O. M., Leahy, K., & Goos, M. (2020). An onvestigation of university students and professionals' professional STEM identity status. *Journal of Science Education and Technology*, *29*(4), 536–546. https://doi.org/10.1007/s10956-020-09834-8

Kleinberg, B., Mozes, M., & van der Vegt, I. (2018). Identifying the sentiment styles of YouTube's vloggers. https://doi.org/10.48550/ARXIV.1808.09722

Laila, E., Sudamin, S., & Prasetya, A. T. (2022). *Integrated Vlog Media Development of Ethno-STEM to Equip Concervation Character and Chemistry Literacy*. In *International Conference on Science, Education, and Technology*, *8*(1), 1121–1128.

Lawrie, G., & Bartle, E. (2013). *Chemistry vlogs: A vehicle for student-generated representations and explanations to scaffold their understanding of structure-property relationships. International Journal of Innovation in Science and Mathematics Education, 21(4).*

Lineberry, L., Lee, S., & Ghimire, A. (2020). Dance-A-Bit: Integrating Dance with Teaching Algorithmic Thinking. *ASEE Annual Conference Proceedings*.

Maj, A. (2018). A healthy mind in a healthy body—Recipes for a healthy living as seen in polish vlogs. *Qualitative Sociology Review*, *14*(2), 116–129. https://doi.org/10.18778/1733-8077.14.2.07

McClain, J., Colina N., R. (2022). "A Tale of Two Classrooms": Designing culturally-relevant hip-hop curriculum to support STEM identity of underrepresented students. *Northwest*

Journal of Teacher Education, *17*(1). https://doi.org/10.15760/nwjte.2022.17.1.3

McLeod, S. A. (2017, Oct 24). Kolb - learning styles. Retrieved from https://www.simplypsychology.org/learning-kolb.html

Morris, T. H. (2020). Experiential learning – a systematic review and revision of Kolb's model. *Interactive Learning Environments*, *28*(8), 1064–1077. https://doi.org/10.1080/10494820.2019.1570279

Ortiz, Morton, Miles, & Roby. (2020). What about us? Exploring the challenges and sources of support influencing black students' STEM identity development in postsecondary education. *The Journal of Negro Education*, *88*(3), 311. https://doi.org/10.7709/jnegroeducation.88.3.0311

Otchie, W. O., Pedaste, M., Bardone, E., & Chounta, I. A. (2020). Can YouTube videos facilitate teaching and learning of STEM subjects in high schools. *Bulletin of the Technical Committee on Learning Technology*, *20*(1), 3–8.

Padirayon, L. M., Pagudpud, M. V., & Cruz, J. S. D. (2019). Exploring constructivism learning theory using mobile game. *IOP Conference Series: Materials Science and Engineering*, *482*, 012004. https://doi.org/10.1088/1757-899X/482/1/012004

Payton, F. C., White, A., & Mullins, T. (2017). *STEM majors, art thinkers (STEM + Arts) – Issues of duality, rigor and inclusion*. *18*(3), 39–47.

Pesare, E., Roselli, T., Corriero, N., & Rossano, V. (2016). Game-based learning and gamification to promote engagement and motivation in medical learning contexts. *Smart Learning Environments*, *3*(1), 5. https://doi.org/10.1186/s40561-016-0028-0

Phelps-Ward, R. J., & Laura, C. T. (2016). Talking back in cyberspace: Self-love, hair care, and counter narratives in black adolescent girls' YouTube vlogs. *Gender and Education*, *28*(6), 807–820. https://doi.org/10.1080/09540253.2016.1221888

Raby, R., Caron, C., Théwissen-LeBlanc, S., Prioletta, J., & Mitchell, C. (2018). Vlogging on YouTube: The online, political engagement of young Canadians advocating for social

change. *Journal of Youth Studies*, *21*(4), 495–512. https://doi.org/10.1080/13676261.2017.1394995

Rodriguez, S., Pilcher, A., & Garcia-Tellez, N. (2021). The influence of *familismo* on Latina student STEM identity development. *Journal of Latinos and Education*, *20*(2), 177–189. https://doi.org/10.1080/15348431.2019.1588734

Runyan, A. S. (2018). What Is Intersectionality and Why Is It Important? *Academe, 106*(6), 10–14.

Ruttenberg-Rozen, R., Powell, N., & Leggett-Robinson, P. (2022). Inclusion is much more than access: STEM capital and agentic strategies. *2022 IEEE International Symposium on Technology and Society (ISTAS)*, 1–5. https://doi.org/10.1109/ISTAS55053.2022.10226643

Seethaler, S., Burgasser, A. J., Bussey, T., J., Eggers, J., Lo, S. M., Rabin, J. M., & Weizman, H. (2020). A research-based checklist for development and critique of STEM instructional videos. J*ournal of College Science Teaching*, *50*(1), 21–27.

Schwartz, M. (2012). Best practices in experiential learning. https://www.mcgill.ca/eln/files/eln/doc_ryerson_bestpracticesryerson.pdf

Shamir, M., Kocherovsky, M., & Chung, C. (2019). A paradigm for teaching math and computer science concepts in K-12 learning environment by integrating coding, animation, dance, music and art. 2019 *IEEE Integrated STEM Education Conference (ISEC)*, 62–68. https://doi.org/10.1109/ISECon.2019.8882015

Shapiro, L., & Stolz, S. A. (2019). Embodied cognition and its significance for education. *Theory and Research in Education*, *17*(1), 19–39. https://doi.org/10.1177/1477878518822149

Sharpe, L., Coates, J., & Mason, C. (2022). Voice, vlogs and visibility: The experiences of young people with SEND engaging in the school games. *Sport, Education and Society*, *27*(2), 134–149. https://doi.org/10.1080/13573322.2021.1900804

Simpson Steele, J., Fulton, L., & Fanning, L. (2016). Dancing with STEAM: Creative movement

generates electricity for young learners. *Journal of Dance Education*, *16*(3), 112–117. https://doi.org/10.1080/15290824.2016.1175570

Smith, T., Avraamidou, L., & Adams, J. D. (2022). Culturally relevant/responsive and sustaining pedagogies in science education: Theoretical perspectives and curriculum implications. *Cultural Studies of Science Education*, *17*(3), 637–660. https://doi.org/10.1007/s11422-021-10082-4

Solomon, F., Champion, D., Steele, M., & Wright, T. (2022). Embodied physics: Utilizing dance resources for learning and engagement in STEM. *Journal of the Learning Sciences*, *31*(1), 73–106. https://doi.org/10.1080/10508406.2021.2023543

Speldewinde, C., & Campbell, C. (2021). Bush kinders: Enabling girls' STEM identities in early childhood. *Journal of Adventure Education and Outdoor Learning*, 1–16. https://doi.org/10.1080/14729679.2021.2011337

Starr, C. R. (2018). "I'm Not a Science Nerd!": STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly*, *42*(4), 489–503. https://doi.org/10.1177/0361684318793848

Steinke, J. (2017). Adolescent girls' STEM identity formation and media images of STEM professionals: Considering the influence of contextual cues. *Frontiers in Psychology*, *8*, 716. https://doi.org/10.3389/fpsyg.2017.00716

Susanti, V. D., Krisdiana, I., Murtafiah, W., Setyansah, R. K., & Masfingatin, T. (2021). YouTube vlog channels in basic mathematics as e-learning during the COVID-19 pandemic. *PYTHAGORAS Jurnal Pendidikan Matematika*, *16*(1), 114–126. https://doi.org/10.21831/pg.v16i1.40932

Voon, X. P., Wong, L. H., Looi, C. K., & Chen, W. (2020). Constructivism‐informed variation theory lesson designs in enriching and elevating science learning: Case studies of seamless learning design. *Journal of Research in Science Teaching*, *57*(10), 1531–1553. https://doi.org/10.1002/tea.21624

Wain, A. (2017). Learning through reflection. *British Journal of Midwifery, 25*(10), 662–666. https://doi.org/10.12968/bjom.2017.25.10.662

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 114. https://doi.org/10.1186/s12966-017-0569-9

Webster, C. A., Dan Michael, R., Russ, L. B., & Egan, C. A. (2019). Learning to integrate movement in elementary classrooms: Field experiences of preservice classroom teachers. *The Physical Educator*, *76*(3), 726–755. https://doi.org/10.18666/TPE-2019-V76-I3-8753

Xie, Q., Liu, X., Zhang, N., Zhang, Q., Jiang, X., & Wen, L. (2021). Vlog-based multimodal composing: Enhancing EFL learners' writing performance. *Applied Sciences*, *11*(20), 9655. https://doi.org/10.3390/app11209655

Yadav, A. K., & Oyelere, S. S. (2021). Contextualized mobile game-based learning application for computing education. *Education and Information Technologies*, *26*(3), 2539–2562. https://doi.org/10.1007/s10639-020-10373-3

Zaferiou, A. M. (2023). Dance-themed national biomechanics day community engagement to inspire our future STEAM leaders. *Journal of Biomechanics*, *150*, 111511. https://doi.org/10.1016/j.jbiomech.2023.111511