ISSN: 2788-5011

SvedbergOpen
DISSEMINATION OF KNOWLEDGE

International Journal
of Education and Teaching

Publisher's Home Page: https://www.svedbergopen.com/

Review Article

Open Access

Revisiting the Plausibility of Learning Style Theories with Evidence of Kinesthetic Perception: A Literature Review and Proof of Concept Towards Justifying Differentiated Instruction

Safia Fatima Mohiuddin[1*]

[1]Researcher and Scientific Writer, MSc Bioinformatics (IASE University), Graduate Certificate Healthcare Management (Clarkson University Graduate School USA). E-mail: safia.fatima@gmail.com

Article Info

Volume 2, No. 1, June 2022
Received : 05 January 2022
Accepted : 19 May 2022
Published : 05 June 2022
doi: 10.51483/IJEDT.2.1.2022.29-47

Abstract

In spite of evidence against learning style theories, educators feel the need for individualized instruction. Complex concepts may require a robust instructional design, learner feedback, and sound understanding of the learning process. This suggests the need to rethink the potential of learning styles in academic success. This paper hypothesizes that inherent traits of learners predisposes them to processing information in a certain way, requiring differentiated instruction for complex concepts. A proof of concept of clarifying the hundredths place for the learner with kinesthetic perception is presented. It is argued that differentiated thematic instruction with movement is ideal to enforce this learning. Success of this methodology suggests its applicability to next-generation classrooms for better comprehension and retention of the subject matter.

Keywords: *Individualized instruction, Movement-based instruction, Kinesthetic perception, Differentiated instruction, Thematic instruction*

1. Introduction

The theory of learning styles is a controversial subject in terms of delivering instruction and learning achievement. Results about its applicability from the statistical analysis have been varied. Still, many educationists continue to explore its merits, in spite of strong refutation from credible sources on grounds of insufficient evidence (Nancekivell, 2019). Ivana performed statistical analysis and found no significant association between learning style and academic achievement (Cimermanová, 2018). However, Bajaj and Sharma maintained that adaptability is integral in educational systems. Customizing content to the student's learning path improves learning efficiency. They proposed an AI-based tool to determine learning styles (Bajaj and Sharma, 2018). Furthermore, the concept of adaptability in learning has also been explored in e-learning systems, where recommendations are guided by flexibility, personalization, and diversity (Wan and Niu, 2018).

It is certain that believing an individual learns in only one specific style is not reasonable. However, the use of a suitable style that relates well to a context and in congruence with learner capabilities may predict higher chances of academic success. This paper presents research and experimental evidence to justify that adapting instruction to learners' needs is essential to learning success. The paper argues that applying holistic teaching style and using

* Corresponding author: *Safia Fatima Mohiuddin, Researcher and Scientific Writer, MSc Bioinformatics (IASE University), Graduate Certificate Healthcare Management (Clarkson University Graduate School USA). E-mail: safia.fatima@gmail.com*

movement to suit learners with predominant kinesthetic perception is imperative in certain scenarios. The terms kinesthetic learner, kinesthetic learning experience, and related terms, used in this paper, relate to scenarios where this style is well-suited. It does not assume that some individuals use kinesthetic learning style exclusively, as all learners are assumed to utilize all learning styles throughout life. To support this hypothesis, a proof of concept of teaching and learning mathematics place value using movement and themes in learning is presented.

2. Kinesthetic Perception and Connection with Learning

Hands-on learning or learning by doing has its foundations in bodily-kinesthetic intelligence. Learners with this style learn well by doing, exploring, and discovering. Actors, pilots, surgeons, crafters, and inventors, often use their bodily-kinesthetic intelligence. Research evidence indicates that traditional instructions may not work for all learners.

Learners who rely on kinesthetic perception remember lessons well when educators combine movement with information. Furthermore, building lessons on a central theme are often effective for this learning style. This process connects subjects and the world to that central theme - a story, historical idea, or a modern phenomenon (Spainhour, 2020; *Kinesthetic Perception*, n.d.; and A Career Guide for the Kinesthetic (Hands-On) Learner, 2018). It is interesting to understand the scientific underpinnings related to the need for this differentiated instruction.

3. Proprioception, Interoception, Exteroception, and Kinesthesia

The primary component of bodily-kinesthetic intelligence is proprioception, with several other senses working closely. During kinesthetic learning experiences, individuals rely on proprioception, kinesthesia, and balance to make sense of new information (Ponzo, 2019). Bodily-kinesthetic intelligence is closely related to proprioception. Proprioception gives you a sense of positioning your body parts in your environment. It also tells you how much strength you need to move about. Examples of proprioception include the ability to step on uneven ground and knowing how hard to press a button. Two other senses closely related to proprioception are interoception and exteroception. Interoception allows you to get a sense of the internal organs, or feel hunger and pain. Exteroception is about perceiving the world around you (*Proprioception, Nociception, Exteroception, Interoception— What do they all mean?*, 2018). While an individual relies on all these senses to understand the working of the body and the environment, the ones most relevant to movement in the learning process are proprioception and kinesthesia.

4. Bodily-Kinesthetic Intelligence, Proprioception and Kinesthesia

The primary component of bodily-kinesthetic intelligence is proprioception. Proprioception gives you a sense of positioning your body parts in your environment. It also tells you how much strength you need to move about. Examples of proprioception include the ability to step on uneven ground and knowing how hard to press a button. Individuals rely on proprioception, kinesthesia, and balance to make sense of new information (Ponzo, 2019; *and Proprioception, Nociception, Exteroception, Interoception— What do they all mean?*, 2018).

Proprioceptors are neural sensors located in our joints and muscles. They help us know the position and movement of our body parts. This awareness is kinesthesia. Proprioception is different from kinesthesia in that it also includes the sense of balance. Deficits in maintaining balance affects your proprioception, but not kinesthesia. This explains why inner ear infections affect proprioception. Proprioception deficits may make it difficult to walk with eyes closed. Kinesthesia is an essential part of hand-eye coordination and muscle memory. Another popular perspective is that kinesthesia relates to the body's motion and movements. It refers to the behavioral component. But proprioception relates to an understanding of these movements – the cognitive component (*Kinesthesia and Proprioception*, n.d.).

5. Prominent Traits of Kinesthetic Learners

According to Howard Gardener's theory of multiple intelligences, kinesthetic learners use their whole body for problem-solving (Marenus, 2020). His theory implies that one may be stronger in a specific area and is able to demonstrate their knowledge and abilities in that area effectively. This helps teachers tailor lessons to the individual needs of learners. Based on this assumption, one may associate certain traits that often occur in learners who achieve better outcomes using kinesthetic perception.

In kinesthetic learners, movement aids their memory, and touching and manipulating objects relate to their learning style. They have a lot of energy, enjoy hands-on activities, and are sensitive to the environment. This means that their learning experiences must contain the use of fine and gross motor skills, tactile sensations, and using the material rather than reading and writing (Logsdon, 2008). Since writing is a tactile activity, learners may sometimes use it for the retention of the material presented during lessons. Props, animations, performances, and the like are the most effective ways to convey subject matter to kinesthetic learners. They engage well with dissecting/taking apart things or putting them together. Roleplay, experiments, demonstrations, and acting out the concept capture the attention of kinesthetic learners.

Kinesthetic learners have very good hand-eye coordination, agility, great timing, and enthusiasm. They enjoy playing with others. Instruction for kinesthetic learners must ideally incorporate many breaks, a lot of movement, and structure. Although they may seem inattentive or unfocused, a personalized learning strategy addresses most of their concerns. They often like to switch positions, tap or swing legs, use fidget spinners, play with textures, or scratch or doodle while learning. Cooking, outdoor play, chores, beach walks, nature walks, art, puzzles, physical activity, rhythm, yoga, and the like, are highly desirable for kinesthetic learners, as they promote relaxation and focus (*The physical (bodily-kinesthetic) learning style*, 2019).

An example of how they relate to physical sensations is the wind blowing against the wings of the airplane. Describing how a person is "feeling" when doing things helps kinesthetic learners understand the topic well (*The physical (bodily-kinesthetic) learning style*, 2019). One example is the way a pilot feels during the taking off and landing of the airplane. Relating the sensations to the mechanical details of the machinery helps with learning. Given these traits and their high levels of energy, it makes perfect sense to incorporate movement in their learning process.

6. Kinesthetic Perception and Information Processing

Learning is a complex process and consists of several interactive components (Davis, 2021). When you learn, you use language and memory. You organize and process information. Learning also requires attention, higher-order thinking, and writing (graphomotor) skills. These aspects of learning depend on interaction with the class environment, teachers, and family, social skill development, emotions, and behavior. Learning style is one's preference to "absorb, process, comprehend, and retain" information. The propensity of a learner towards a learning style depends on experience. This inclination is also influenced by cognitive and emotional factors, and the environment.

The kinesthetic processing system is also known as the haptic processing system, and interprets, organizes, and stores the meaning of information we take in through touch (tactile) or movement (kinesthetic). Closely related to the kinesthetic processing system is the vestibular system, which oversees balance and spatial organization. How one senses balance influences the information we take in through touch or movement. Information is received through mechanoreceptors located in joints, muscles, tendons, skin, and the vestibular system. To put it differently, exploring objects in space triggers haptic input. The haptic system is very important in learning as it influences reading ability, laterality, directionality, contact, locomotion, sensory integration, and spatial awareness. Therefore, these systems are deeply connected to learning achievement.

7. Brain Regions and Processes in Learning and Hands-On Skill Mastery

Several regions in the brain are activated in hands-on learning for skill mastery. As we progress in the learning process, our brain adapts to help us achieve a higher level of competence. Our brain directs our muscles to perform in different ways every time we get closer to mastering the skill. When we master new skills, certain changes occur in the brain. As a result of these changes, the brain sends out different information to muscles to alter movements.

Different types of memory are controlled by different brain regions. Learning new skills is associated with modifications to the primary motor cortex. Consequently, connections are formed between cells in the primary motor cortex and the neurons traveling along the spinal cord. These neurons connect with the muscles involved in the skill mastery. The muscles initiate contraction and movement. Other areas involved in skill training are grey matter and white matter. When a new skill is learned, there is also a lot of activity happening in the premotor cortex and the basal ganglia. This activity decreases with more practice when doing the skill becomes effortless. When you have mastered a skill, certain processes continue in the cerebellum and motor cortex. The purpose of these processes is to add to the focus with which you can perform the tasks relating to the skill.

8. Muscle Memory and Kinesthetic Learning Experiences

Muscle memory, a form of procedural memory, is an integral component of kinesthetic learning. It is the procedural memory that enables a person to perform an action without being consciously aware. Scientific evidence says that you can build muscle memory by repeating a task over time, so that you need minimal attention and conscious effort in performing the task efficiently. Muscle memory enables us to do a task faster and better with practice. In a research study, surgeons undergoing training successfully used kinesthetic information when visual feedback was limited (Pinzon *et al.*, 2017). Connections between sensory nerve receptors in muscle and tendons and the brain are very strong in kinesthetic learners. This means that information taken in by the way of movement and touch is readily absorbed and retained by their brain. As a result, kinesthetic learners prefer hands-on activities and whole-body involvement in learning.

9. Integrating Movement into the Learning Process

Incorporating movement in learning allows the integration of all senses. Information processing with kinesthetic perception is a three-dimensional learning experience. An essential component of kinesthetic learning is motor planning. Motor planning refers to problem-solving, planning, and action associated with movement. Motor planning and muscle memory are closely related and enable coordinated movement, such as the act of buttoning up the shirt without looking at it. In this context, we use proprioception to make the necessary calculations for weight and position in space or the degree of pressure or force to apply to do an action.

Movement in the learning process has been explored for a long time. About two decades ago, Stevens-Smith discussed how movement in learning leads to interconnected neurons, and that movement serves as a stimulus to create these connections between the ages 2 and 11. More connections mean a more profound ability to assimilate information, solve problems, and think. Stevens-Smith related that moving and learning is the best way to absorb information (Stevens-Smith, 2004).

In recent papers, researchers reconfirm the association between physical activity and cognitive-motor skills (Mendes *et al.*, 2021). Lindt and Miller explored an elementary school setting to conclude that integrating movement in learning math, reading, and other subjects, contributed towards greater academic achievement. The impact of movement in the learning process can be felt in terms of enhanced engagement, motivation, and interest, leading to improvements in skills, content knowledge, and test scores (Lindt and Miller, 2017). The approaches used for the purpose were dancing for better retention, relating content with movement, organizing learners, moving across the room, and connecting actions and ideas. This validates the idea that movement in learning leads to the integration of all senses and promotes motivation, attention, and better academic outcomes. Given this information, the next section covers successful and proven strategies for the kinesthetic learning style.

10. Differentiation in Teaching and Inclusion of Movement

The general belief among educators is that students rely on a dominant style of learning while combining different styles as they need. This requires teachers to have specialized knowledge, resources and tools to cater to learning presented through different modalities. Modern scientific evidence points at the validity of multisensory teaching as a means to achieve deep learning in a diverse student group. Such an approach may be the way forward to fostering an ability to think about concepts at a complex level and retain content that was learned successfully. Several theories, arguments, and strategies are applicable to this discussion, as explained in the sections that follow.

11. Experiential Learning – A Popular Learning Theory

Relevant to the argument about tailoring teaching approach to the learning style, is the experiential learning theory by David Kolb. According to Kolb, learning is holistic and dynamic, a two-dimensional process, which involves taking information and transforming it. The experiential learning theory says that people learn from experience. The learning cycle defined by this theory consists of four different modes: Abstract Conceptualization (AC), Reflective Observation (RO), Concrete Experience (CE), and Active Experimentation (AE). Learning is viewed as a major process in human adaptation that involves the whole person, and affects life, cultures, and contexts (Sharma and Kolb, 2010). That said, it is important to assess what research evidence says about links between learning style and learning achievement.

12. Links Between Learning Style and Learning Achievement

Several studies have reported that there is no significant association between learning styles and learning achievement. Zacharis compared a group of online students with on-campus learners to understand if their learning style affected online or face-to-face delivery mode (Zacharis, 2011). They found no statistically significant results supporting the argument that learning styles affect learning performance. Davis and team worked with the Kolb learning model to better understand course design and learner needs (Davis and Others, 1988). They used the Kolb learning styles inventory with four learning styles—convergers, divergers, assimilators, and accommodators. They found no significant differences in grade point average of the students belonging to these four categories.

On the contrary, several other research studies identified that learning styles did matter and differentiated instruction was imperative. Research on nursing students carried out by Vizeshfar and Torabizadeh maintained that it was important to recognize the learning styles of students and tailor teaching methods to match them (Vizeshfar and Torabizadeh, 2018). In a sample of nursing students, Kolb's nursing style questionnaire was used as a means to evaluate the dominant learning style. Their conclusion indicated that learning styles played a major role in enhancing learner achievement and teacher satisfaction, which has implications in training professional nurses. Huang and colleagues showed that participation in an e-learning environment was dependent on the learning style (Huang *et al.*, 2012). The sensory/intuitive dimension of learning styles predicted learning performance in e-learning environments by mediating online participation. Sensory learners had a higher level of online participation and intuitive learners had a lower level of participation. Miller identified that learning preferences did matter by presenting students a resource, the Programmed Learning Sequence (PLS) in different formats (Miller, 1998). Overall, students gave a higher score to PLS in comparison with the traditional method. Students of the sonography class scored better with book PLS rather than computer PLS. Further, students who learned with the book PLS preferred a quiet environment, while those who learned with the computer PLS preferred more light. Students who preferred the traditional method also preferred to have an authority figure.

Several other studies indicated that the nature of interactions between different variables was unique for specific student populations. In other words, more than one variable affected the way learning style preferences influenced learning achievement. Nurlaela and colleagues identified that learning achievement was significantly different in students who used a thematic learning model, as opposed to a conventional model (Nurlaela *et al.*, 2018). Second, differences also existed in students who had a visual learning style versus those who had an auditory learning style. Third, reading ability predicted learning achievement. Specifically, the interaction between the instruction model and learning style was a predictor for learning achievement. Other interactions among these variables were not found to be significant, and researchers stressed that a thematic model had the potential to incorporate many different learning styles into the instruction. Broadly speaking, learning styles do matter in certain situations, and thematic and differentiated instruction is highly desirable.

13. Advantages of Differentiated Instruction with Kinesthetic and Tactile Strategies

The advantages of physical activity are well known—promoting cardiorespiratory fitness, improving white matter integrity, enhancing communication between brain regions, improving volume of grey matter, and improving cognition and creativity. Recent research connects this idea with learning and uncovers how physical activity plays an essential role in improving academic performance for all types of learners.

Among the different learning styles, preparing differentiated instruction for kinesthetic learners may be a challenging task. Educators need to additionally plan physical movement and tactile activities that go into making a cohesive lesson plan for kinesthetic learners. These lesson plans are targeted at physically active learners who need to move around and engage their body and sense of touch in learning experiences. In other words, kinesthetic learners are more attentive with "hands-on" lessons and find it hard to retain their attention simply using notes, lectures, and even videos.

Lessons incorporating movement and touch could be as simple as associating foot tapping or clapping with concepts. Teachers may make hand gestures to help them remember. Some classrooms incorporate physical movement such as pacing or bouncing a ball while learning the concept. Many teachers use handwritten notes for tactile stimulation and incorporate hand-eye coordination or gross motor skills into the learning activity. The best teaching strategy results from a collaboration between students and teachers to arrive at a personalized lesson plan.

14. The Mind-Body Connection and Movement

The mind-body connection helps us to learn effectively. Problems can be perceived from multiple angles and creative problem solving is a rigorous approach. Kinesthetic learning combines different ways of learning to improve the way we comprehend and retain information. Movement during learning experiences puts students in a "receptive state" to help them learn well. In a learning experience for middle school girls, algebra is taught with movement - doing $3x + y$ as three twirls and one jump, assuming "where x = twirl, y = jump". Being able to instantly get a sense of the concept boosts confidence levels for learning success (Sinha, 2014).

15. Differentiating Mathematics Instruction with Storytelling

Storytelling in mathematics encourages learners to enjoy the subject and engages them. Digital storytelling allows personalization of the learning experience, decodes difficult concepts, makes use of real-life contexts, and makes the learning process interesting. Storytelling is a tool for active learning with improved motivation and achievement. In a study conducted by Ilknur and colleagues, researchers found that students participating in the activity had higher achievement scores. The process facilitated associations with daily life while making the learning more enjoyable and interesting. Students participated well in the class and had a positive opinion about digital stories (Özpinar *et al.*, 2017). While numerous models have been presented in this area, an interesting use of storytelling was demonstrated in the learning of fractions among third-grade students. Results indicated that the use of digital storytelling enhanced student achievement, especially those with low or medium performance. They were also able to develop related mathematical skills such as finding equivalent fractions and comparing fractions. Learners also developed the essential skills of problem-solving and manipulating representations (Lemonidis and Kaiafa, 2019).

16. Relevance of Multimodal Instruction to Learning Style

According to cognitive psychologists, memory is stored as the meaning rather than the type of input (for example, perceiving a concept by seeing it, hearing it, or touching it). This conclusion was derived from memory tests which revealed that people thought new sentences belonged to a story they heard earlier as their meaning was coherent with the original storyline. The exact sentence, however, was not present in the original story. Further, memories are stored in several formats such as in the form of pictures, sounds, or as the meaning. Everyone is made differently, and while some may have a stronger visual memory, others may have a stronger auditory memory, and so on (Willingham, 2013). This means that when the information is presented for the stronger modality of learners, they are more likely to learn the concept well and retain it. On the flip side, most subjects may not require a direct visual or other representation, and storing the meaning may be all that is needed to meet learning goals.

Research evidence, on close scrutiny, reveals that delivering instruction in the child's strongest modality makes learning more interesting, and helps to organize the material better. It is rather hard to prove the idea that the use of better material could also have created a better learning experience (Willingham, 2013). However, there is always a possibility of the availability of convincing evidence concerning tailoring instruction based on the learner's preferred modality. Drawing on the available research evidence, educators recommend delivering instruction in a modality that suits the content such as presenting a visual when they want students to remember how something looks.

17. Relevance of Constructivism to Learning Style

Finally, it is worth mentioning here that constructivism, a popular educational philosophy, caters to different learning styles. Constructivism maintains that students construct their unique knowledge in the learning process, based on their experiences, beliefs, and newly acquired knowledge. Instructional strategies must address these needs of students, and it is essential to examine individual learning styles. Miller explored the link between constructivism and learning styles in the context of statistical learning. Miller maintained that a teacher facilitates construction of new knowledge for different types of learners in a continual process of adapting instruction to the student and the concept. The application of constructivist theories can be complicated, but suits all learning styles (Miller, 2002).

18. Movement-Based Instruction and Enhanced Math and Reading Performance

Several studies have indicated improvement in academic performance when learning is blended with movement. Motor skills, academic performance, and Moderate-to-Vigorous Physical Activity (MVPA) have a definite correlation according to a Danish study carried out on preadolescent children (Beck *et al.*, 2016). Integrating movement into the concept being taught using low intensity activities was found to be effective, indicating the need for novel forms of instruction. This sort of instruction must incorporate physical activity pertinent to a lesson for personalized learning and enhanced motivation. Deeper research into the specific brain areas and motor systems involved in learning is essential to understand the whole picture. This type of instruction may have a positive effect on reading, and needs to be validated through sound research.

In another study, fourth-grade children were delivered instruction in geometry using an integrated approach, which proved to be an efficient teaching method (Hraste *et al.*, 2018). The positive effects of this teaching method were improved motor coordination, memory, balance, better reading, math, speech and language skills, and reduced anxiety and hyperactivity. Mind-body integration is an essential aspect of learning. First, motor and cognitive development are interrelated. Further, fine-motor coordination is a "prerequisite" for attention and visuomotor integration. Finally, visuomotor integration is an essential aspect of "concurrent and longitudinal mathematics achievement". Students represent and understand numerical information spatially when they interact with physical objects. Incorporating exercise into the instruction leads to faster mental reactions and faster adaptation to new scenarios. It alleviates mental fatigue, depression, and aggression.

Furthermore, in a study that jointly explored the role of spatial and motor skills in mathematical ability, 6-8 year old children showed that visuospatial reasoning, mental rotation, and fine motor skills predicted success in mathematics learning (Fernández-Méndez *et al*., 2020). Mental rotation is a critical spatial skill that can be specified as intrinsic extrinsic (relations between objects vs relation between object and context). The other dimension of mental rotation is static-dynamic (retaining static presentations vs. transforming a stimulus). Mental rotation serves as a cognitive tool to form mathematical representations. It is just one of the measures of spatial abilities, and several other measures including visuomotor integration, visuospatial working memory, perspective taking, and map reading are all related to mathematical abilities. Further, balance and manual dexterity improve cognitive performance. Finally, motor skills enhance mathematical performance, and have a correlation with spatial abilities.

19. Understanding Learning Differences for Effective Teaching

Price, Dunn, and Sanders argue that there is no single approach that fits the preferences of all students, and teachers do not have the training to map an approach to a specific learner type. They call the approach to introduce a single teaching strategy to a whole class, a "hit-or-miss experiment" (Price *et al*., 1981). This, they say, is true regardless of the plausibility of the teaching strategy, whether it is teaching phonics, word recognition, or using real-life situations to teach concepts.

Understanding a child's potential is not a straightforward process. There is limited evidence on associating the specific variables to learner types for effective learning processes (Price *et al*., 1981). Researchers observe that schools have "inappropriate and inefficient data" to address this problem. An IQ examination is inadequate as it only tests the rate of learning when the key questions that must be addressed relate to understanding learning blocks and emotional problems.

Price and team suggest that the starting point here is to understand that some learning methods work well on some students and not others. Secondly, accepting the idea that learning differences exist is a key aspect of forming a purpose to explore alternative methods of learning (Price *et al*., 1981).

20. Critical Thinking and Learning Styles

Myers and Dyer of the University of Florida tried to understand if learning styles influenced critical thinking in students of agriculture. Critical thinking has many definitions, with the most basic one being, "reasonably deciding what to believe and do". Interestingly, critical thinking is linked to several variables including academic major, gender, cognitive ability, and grade point average. Besides, critical thinking undergoes significant changes overtime, such as improved cognitive skills leading to better critical thinking ability (Myers and Dyer, 2006).

Myers and Dyer focused on understanding deeply embedded learning styles. In a leadership development course conducted for the target group, students were perceived to use one of the learning styles among abstract sequential (intellect, reason, and logic based; prefer metally stimulating environment), concrete sequential (structured, task-oriented; categorize facts and figures to solve problems), abstract random (feeling and emotions tied to thinking; learn in colorful environment without routines), and concrete random (rely on intuition and instinct; risk-takers, competitive, and creative; rely on attitudes rather than facts; jump to rapid conclusions) (Myers and Dyer, 2006).

Researchers found that only the students who were identified by the "deeply embedded abstract sequential" learning style scored higher in terms of critical thinking skills. Intriguingly enough, critical thinking was not significantly associated with any of the three other learning styles (Myers and Dyer, 2006). This critical thinking research identified that some learning preferences were very deeply embedded and could not be adapted to alternative learning preferences in certain environments.

The conclusions of researchers were based on analyzing, ordering, and the perception of the students in the study group. Perceptual abilities are the means that an individual employs to grasp information. Perceptual abilities can be visualized on a continuum of abstractness on one end and concreteness on the other. For example, while some individuals perceive things as black and white, others may see only shades of gray. Ordering is about arranging, systematizing, and referencing information. The continuum of ordering consists of sequence on one end and randomness on the other. Examples of differences in ordering are filing in alphabetical order, or stacking neatly, or just using open space in a random way (Myers and Dyer, 2006).

The four learning styles represent the location of an individual on these continuums (Myers and Dyer, 2006). In general, researchers indicated that when a learning situation digressed very far from the preferred learning style of an individual, it became difficult to meet the demands of that learning environment. In effect, they found the need to introduce appropriate teaching techniques to match the learning style of students.

21. Outcomes of Differentiated Instruction with Movement

A significant portion of research justifies the need for appropriate teaching methodologies in certain groups of learners. It would be appropriate at this point to say that kinesthetic learners have an advantage when movement is integrated into the learning process. Therefore, they require differentiated instruction. The following section elaborates on this idea.

22. The Need for Differentiated Instruction for Kinesthetic Learners

Schnarr presents research evidence on the value of differentiated instruction for kinesthetic learners (Schnarr, 2016). He argues that "differentiated learning" and "individual education plans" give every student a fair opportunity to succeed. Present classrooms look at this differentiation based on the intelligences of learners. In this context, kinesthetic learners have received less attention concerning personalized lesson delivery.

Schnarr argues that authentic, healthy classrooms must have differentiated instruction to support bodily-kinesthetic learners (Schnarr, 2016). These instructions must be organized around specific goals and strategies leading to experiences that build competence and confidence, create opportunities across subject areas, and target predetermined outcomes. In most classrooms, kinesthetic learners seem to be "overshadowed" by visual and auditory learners. The idea of developing multiple intelligences relates to an "individual-centered school" that addresses each student's unique cognitive profile. This idea implies that people differ in terms of their interests and abilities. Differentiation for learners requires innovation and reflection and leads to learner empowerment.

23. Kinesthetic Perception and Thematic Learning

Lessons guided by a theme serve as a way to make connections between activities, skills, and subjects during learning experiences. Themes make learning interesting, allow learners to explore, stimulate their natural curiosity, motivate them, all of which lead to deep learning. Children are able to see the world as an interconnected place and observe subtle relationships between subjects, which spurs innovation and creativity.

There are a number of ways to incorporate themes into lessons. Themes can be in the form of stories, real-world events, the environment, or anything that makes learning meaningful and gives them a chance to apply different inherent intelligences. For example, in a lesson about planes, one may include a range of learning activities such as reading about planes, making planes, runways, and airports, watching planes take off and land, role-playing car and plane journeys, and reciting poems and watching movies about planes.

In a research study that evaluated kinesthetic measures as "space-visuomotor task accuracy" for the level of on-task behavior in thematic learning, kinesthetic perception with physical activity recorded a better performance in science, math, and reading (Yulianti *et al.*, 2019). This study demonstrated that there is a definite link between on-task behavior in thematic learning experiences and the use of physical activity for learners with kinesthetic perception. Thematic learning involves multiple disciplines and makes connections between subjects and real-life phenomena. This study demonstrated that kinesthetic perception and physical activity influence on-task behavior positively. Kinesthetic perception was found to have deep links with mathematics.

In essence, every child is made differently with a unique set of strengths. Next-level classrooms need to imbibe this by presenting information through strategies that benefit all types of learners. Kinesthetic learners require instruction through tactile and kinesthetic stimulation, which means expending resources and knowledge towards a cohesive theme that appeals to these learners. In the next few sections, a proposed solution describing the case of teaching place value using a thematic differentiated approach is presented to encourage thinking and retention at a new level.

24. Scenario Discussion: Differentiated Instruction for Teaching Place Value

Place value is a fundamental building block of primary mathematics education. The place value system relates to arithmetic capabilities (Herzog *et al.*, 2019). Experts believe that the understanding of the place value system predicts math performance and math difficulties.

Understanding place value means getting a hold of position, base-10 rules, and multi-digits. The principle of position applies to base-10 rules (Cheung and Ansari, 2020). When numbers change position, they have different magnitudes. In their example, researchers identify that in 65, 6 and 5 have different positions. These positions are "ordered values of different magnitudes". Understanding position precedes the understanding of multi-digits in place value. Ansari and Cheung intended to understand when children acquire "positional knowledge of multi digits"or how they related position and value. They found that learning number names helped to understand the positional property of place value.

Sari and Olkun explored how a sound understanding of the place value system was essential to solving arithmetic and performing well in mathematics. Fourth-grade students were observed and results indicated that regardless of whether the student was a male or female, place value was a definite milestone in the arithmetic and mathematics learning process (Sari and Olkun, 2021). Place value serves as a foundation to develop an understanding of fractions, operations on large numbers, decimals, measurement, and many more advanced mathematical concepts. Gaps in learning place value might make it difficult for learners to understand complex algorithms.

25. Metonymic (Ordinality) and Metaphorical (Cardinality) Approaches

Place value is an integral aspect of developing a good number sense. Coles and Sinclair highlight the difficulty faced by children when getting on to the hundredth's place (Coles and Sinclair, 2017). They narrate a common incident where the child refers to a hundred as "tenty", as it is followed by "ninety" (a child may deduce this language pattern as ten comes after nine, so tenty comes after ninety). This indicates the need educators feel about helping children get the right "sense" of the hundred. Only when the child knows what a hundred is, is it possible to understand the tens and ones that follow it to make bigger numbers. Researchers observe that counting and patterns in language is one aspect that children may rely on to advance in the different digits in place value, such as in the case of ninety and tenty indicated above. Children may sometimes map nine and ten of the units place to ninety and tenty of the tens place during the initial stages of teaching tens digits.

From a neuroscience perspective, numbers have a visual code, verbal code, and magnitude code (digit representation, spoken words, and analogical quantity). Educators have used ordinality and cardinality, or sometimes a combination to build this sense. Place value is often associated with understanding the whole quantity as the sum of digits (additive property), positions of digits in the number (positional property), the value obtained from multiplying the face value of the digits with the value of the position (multiplicative property), and increase in value of positions in the power of ten when viewing from right to left (base ten). Researchers have indicated that the general focus of place value education is metaphoric, focusing on cardinality, rather than metonymic, focusing on ordinality (Coles and Sinclair, 2017).

Another popular approach is the structuring of the numbers on a Gattengo chart, which supports visuospatial numbering patterns. Learning with the Gattengo chart involves calling out number names while tapping or pointing at the numbers. Researchers believe that the Gattengo chart and other such tools (including handheld electronic touchpads) engage learners with the metonymic representation of numbers and help them form connections between "symbols, sounds, names, touch, and gestures". Focusing on metaphoric and metonymic approaches may create the right balance between cardinality and ordinality approaches for learning during the early years, and minimizing problems during the later stages.

26. Modeling and Structure Approach

Brendefur and colleagues recommend a "modeling perspective" to understand the concept of place value. They utilized the bar model to show quantity and units. The model helped students differentiate units from tens. They were also able to show an understanding of teen numbers. Their research proved the effectiveness of visual models to understand place value (Brendefur *et al*., 2018).

Modeling helps develop mathematical thinking and mathematical reasoning. The bar model consisted of thinking of one cube as a "unit of 1" and then drawing the required number of cubes, one on top of the other to get to the desired number. To show tens, ten cubes lined up in a row were covered by tape and presented as "1 unit of size 10". Educators conducted an interactive activity to understand different perspectives. Representations of teen numbers consisting of tens and ones models were also shown to students. They demonstrated jumps of tens and ones on the number line to model larger numbers (Brendefur *et al*., 2018). Overall, modeling and structure were effective teaching approaches. Students were able to understand differences in "relative size of quantities" and between number and amount represented. They were able to compare "number length" and digit positions. Students learned the skill to create "proportional representations of numbers". Finally, they were able to use language to describe place value in the right context.

27. Use of Language to Strengthen Place Value Understanding

Mathematical language and vocabulary can be an important tool in learning place value. Disney and Eisenreich explain how to use **d**iscourse to "make sense" of mathematics (Disney and Eisenreich, 2018). They advocate student-centered classrooms to promote autonomy in young children. Effective communication in the math classroom is essential to engage students in "explanation, justification, questioning, and sense-making". Discussions and activities in the classroom and interaction with peers is the path to creating new knowledge. Discourse in the form of oral and written communication supported by visual representations promotes asking questions, making clarifications, developing literacy, comparing problem-solving strategies, and mastering speaking and listening skills.

Hands-on models serve as great tools for grouping and making sense of tens and ones. These models act as starting points to promote discourses and understand the relation between tens and ones (Disney and Eisenreich, 2018). Discourses not just encourage student engagement but adding a context to explain place value also promotes mathematical reasoning. Researchers indicate that the context of a candy shop serves as a reason for students to group by ten. Using different objects for hundreds, tens, and ones, accompanied by inquiring students about approaches used to make sense of problems promotes a deep understanding of place value. The language approach (using a candy shop context) proved to be effective in deep learning complex aspects of place value.

28. Proof of Concept of Language, Movement, and Whole Body Involvement in Teaching Place Value

Place value is particularly challenging for children with mathematics difficulties. Lambert and Moeller investigated strategies used to process place value. They studied third-grade students to understand how they computed two-digit addition. In doing so, they found that children with math difficulties made errors, especially in carryover (Lambert and Moeller, 2019). Scientists indicated that this pointed at impairment in understanding place value. They found a relation between computing place value and its strategy and working memory.

MacDonald and team used a constructivist approach, engaging students through the use of mathematical materials to explore childrens' understanding of multi-digit numbers (MacDonald *et al*., 2018). The purpose of their study was to identify the precise methods that work well to support low achieving learners with a sound understanding of multi-digits. Researchers assessed the understanding of the study group by working with counting questions, forming groups of tens, decomposing, and regrouping. They also tested number relationships and comparison. Students found it difficult to infer digits according to their place value positions (for example, researchers indicated that children treated 3 as 3 in 34 rather than 30). Such an example refers to a difficulty with transitioning from single-digit to multi-digit numbers by "interiorizing the concept of ten"). They enforced the use of concrete materials to help learners "coordinate two levels of units". The use of concrete material is also essential to develop an understanding of the three levels of unit coordination. Interiorizing two or three levels of units was essential for students to find the number between two specific multi-digit numbers. Being unable to find numbers in between two multi-digit numbers, therefore, referred to the learner's difficulty with interiorizing different levels of units. Furthermore, being able to perform operations on numbers required students to develop sophisticated and flexible part-whole relationships.

29. Proof of Concept Overview: Problem of Understanding the Hundredths Place

A series of learning strategies were undertaken with a Grade 2 learner in a homeschool setting. The motivation to carry out a series of lessons using different approaches was spurred when the learner was not able to connect the way in which tens advance to hundredths place, thereby making it impossible to move further to explain increasing numbers in the place value system. It was important to experiment and discover alternative teaching strategies to assist the learner gain a true sense of place value, in a way that makes it possible to apply it to real-world scenarios seamlessly. The learner possessed the traits of learners with kinesthetic learning style as discussed in the beginning of the paper. Therefore, it was assumed that the learner was predisposed to kinesthetic perception, and the incorporation of movement in line with the lesson theme may be worthwhile (movement-based thematic differentiated instruction).

As discussed in the review of literature in this paper, differentiated instruction incorporating evidence-based strategies is viable and solves the problems associated with understanding place value. The stakeholders affected by this success of this proof of concept are learners, parents, and educators who may be faced with similar challenges. The effectiveness of the proposed strategies were personalized and tested for a single learner. Success with the comprehension and retention of the hundredths place was tested using traditional written exercises provided prior to and after the implementation of thematic movement-based lessons. These thematic movement-based lessons are discussed in the section on methodology below. Accurate completion of written exercises after the implementation of the methodology was considered an indicator of success with the understanding of place value.

30. Methodology: Differentiated Holistic Instruction with Movement and Narration

The following approaches were used to gain a sound understanding of the hundredths place with success. All modalities (written exercises, tactile manipulatives, modeling and structure approaches) of instruction were presented to the learner, but the complete understanding, sense, and meaning of place value, i.e., advancing to the hundredths place were gained only after integrating movement and whole-person approach in the learning process. The strategies used in the activity are storytelling, language, movement, and tactile manipulatives, all integrating to cater to a dominant kinesthetic learning style. It must be noted that the learner did not indicate a preference for a specific style of learning and instruction. While other modalities were not successful in driving home the "hundredths" concept, the use of movement, thematically, contributed towards the learning (interiorization) of this complex elementary mathematics concept.

A purposeful and meaningful approach to teaching place value is storytelling. Mathematics-based digital stories form connections between "visual, auditory, and verbal representation" in the problem solving and critical thinking aspects of mathematics learning (Walters *et al*., 2018). Digital technology for multimodal approaches promotes engagement and motivation. Storytelling is an important tool to create "interesting and enjoyable learning environments" in mathematics (Özpinar *et al*., 2017). Finally, digital storytelling fosters creativity and identity development while encouraging connections with peers (Kim and Li, 2020).

31. Implementation: Storytelling, Context, and Movement to Get to the Hundredths Place

Learning place value can be exciting with a storytelling approach. In the following activity, storytelling is used in a holistic style, encouraging the learner to use movement and the whole body to make sense of the position and magnitude of numbers. To design the activity, the learning principles of prominent educationists, Charlotte Mason and Rudolf Steiner were followed. The aspects of a nature-inspired setting and the use of story and narration are Mason's recommendations, and were incorporated in this activity (*Who is Charlotte Mason?*, n.d.). Further, the core principles of Steiner's philosophy, i.e., making and learning to promote entrepreneurship and dwelling on the subject matter to interiorize it were applied (Steiner Waldorf Schools Fellowship, 2019; *and Everything You Need To Know About The Steiner Approach*, 2018). Storytelling is the central tool to introduce the concept of ones, tens, and hundreds. The learning activity uses context to understand how numbers progress in their magnitude with respect to position. This activity was published online (Anas Learns, 2015a; and Anas Learns, 2015b).

32. Feasibility Analysis: Validation of Best Practices in Pedagogy

Although the activity was tested on a single learner, the learning strategies devised for the purpose were evidence-based, applicable, and valid for modern contexts and scenarios. Firstly, the philosophies of pedagogy of prominent educationists applied in this method have been highly successful over decades. Furthermore, the lesson devised to decode the understanding of the hundredths place comply with best practices in pedagogy and are based on research evidence.

An appreciation of innovative pedagogical approaches has been discussed by many authors such as Burns and Paniagua, where they explain the purpose of pedagogies, the value of adapting teaching to student needs for increased productivity, and combining pedagogies for innovative outcomes (Peterson *et al*., 2018). They discuss these ideas with relevance to mathematics, social learning, and language. However, a high level perspective on best practices in pedagogical approaches is presented by Pearce and colleagues. Pearce and her team, in their review entitled "What Makes Good Pedagogy" enlist research claims on effective pedagogy, which are used as measures to compare the current methodology and justify its validity (Pearce and Husbands, 2012).

The researchers maintain that effective teaching must include "pupil's voice", consulting them, involving them in decision-making, and tailoring instruction based on feedback. Since the methodology was a child-led learning approach, the learner was involved in not just choosing strategies but also designing lessons (craft work, story design, character sketch, story narration, and role play). Furthermore, the feedback of the learner following different activities was used to make an assumption of kinesthetic learning style and determine the suitability of movement-based thematic instruction in mathematics. The authors indicate that education must be based on well-established theories and "address the characteristics of the learner" (Pearce and Husbands, 2012). These aspects were integrated in the instruction as it was based on the philosophies of Charlotte Mason and Rudolf Steiner, as well as modern evidence-based theories. The learner characteristics were carefully studied and evidence of kinesthetic perception was observed, leading to personalized instruction.

Authors specify the importance of short-term and long-term outcomes and these areas were addressed. While short-term goals of understanding the progression from the tenths to the hundredths place were achieved, the essential aspects of entrepreneurship, real-world application of concept, physical fitness, nature-inspired learning, and emotional intelligence were integrated in the learning process by applying the philosophies of Mason and Steiner. Authors indicate the need to incorporate the prior learning experience of students, and the theory of experiential learning was given due consideration while designing the lesson plan. This helped discern the exact nature of misunderstanding about the hundredths place, i.e., the difficulty to correlate magnitude and position of digits. The authors state the importance of child readiness for learning, constructivist approach, social context, and the use of a range of techniques. All these aspects were integrated in the methodology while elucidating the context and storyline. Prior understanding of the concept of big and small, animal characters, the use of colors and textures, and a variety of natural settings promoted interest and deep learning. Finally, the authors explain the importance of asking questions, assessments, and looking at diverse needs of learners. These aspects were also blended with the holistic lesson delivered for the purpose. Learning was assessed through a teach back approach and success was finally achieved with traditional written assignments. Therefore, on the basis of this comparison, it may be deduced that the methodology follows the essential elements of best practices in pedagogy and can be extended to diverse next-generation classrooms.

33. Results: Successfully Making Sense of the Hundredths Place

At the end of the activity, the learner was successfully able to use movement, which was part of the story, and connect magnitude and position, gaining a "sense" of the hundreds place, alleviating the complexity, and interiorizing it for real-world application. Following the success of the activity, the learner was also able to complete the written activity on place value accurately. This proved that a sound understanding of the concept was gained after the incorporation of movement in a thematic manner, dwelling on the concept for an extended period of time from design to implementation, and conceptualizing and narrating a story to connect the pieces together. The overall activity and teach-back was enjoyable and did not lead to any unintended or negative outcomes. The learning process was greatly enriched by the culmination of multiple approaches.

34. Future Direction: Ascertaining when Movement-Based Instruction is Imperative

Therefore, the incorporation of movement in learning experiences may be necessary to those learners who display the traits of kinesthetic learning style. The learning experience presented in the paper demonstrated that movement, when combined with a theme, drives home difficult concepts such as place value. A whole-person approach that uses the integration of all senses in a learning experience, is, therefore, highly recommended for academic success.

A similar activity demonstrating a movement-based approach to teaching place value using poetry and role play is included in the Appendix.

35. Conclusion

Beyond the proof of concept presented in the paper, several other scenarios were discussed from existing literature that also support the use of movement in learning. To reiterate, the paper mentions many occasions when it becomes imperative to use this approach. Controversies surrounding learning styles may be resolved by conducting more experiments to explore the effect of movement and a central theme on learning and academic success. These studies may be conducted with a diverse group of students, and may help clarify the precise instances when it is absolutely necessary to personalize instruction to individual learner traits and preferences. Exploratory studies in this direction may open up novel methods of achieving deep learning spontaneously, while doing away with inefficient rote memory methods or the "one-size-fits-all" paradigm.

References

A Career Guide for the Kinesthetic (Hands-On) Learner (2018). UTI Corporate. https://www.uti.edu/blog/education/kinesthetic-learner.

Anas Learns (2015a). *A Story of Place Value - Part 1*. Www.youtube.com. https://www.youtube.com/watch?v=bNEDnxu8SQc&t=101s

Anas Learns (2015b). *A Story of Place Value - Part 2*. Www.youtube.com. https://www.youtube.com/watch?v=ITUwhjjigNo&t=1s

Bajaj, R. and Sharma, V. (2018). Smart Education with Artificial Intelligence Based Determination of Learning Styles. *Procedia Computer Science*, 132, 834-842. https://doi.org/10.1016/j.procs.2018.05.095

Beck, M. M., Lind, R. R., Geertsen, S. S., Ritz, C., Lundbye-Jensen, J. and Wienecke, J. (2016). Motor-Enriched Learning Activities Can Improve Mathematical Performance in Preadolescent Children. *Frontiers in Human Neuroscience*, 10(2016). https://doi.org/10.3389/fnhum.2016.00645

Brendefur, J., Strother, S. and Rich, K. (2018). Building Place Value Understanding Through Modeling and Structure. *Journal of Mathematics Education*, 11(1), 31-45. https://doi.org/10.26711/007577152790019

Cheung, P. and Ansari, D. (2020). Cracking the Code of Place Value: The Relationship Between Place and Value takes years to Master. *Development Psychology*, 57(2). https://doi.org/10.31234/osf.io/zqpdw

Cimermanová, I. (2018). The Effect of Learning Styles on Academic Achievement in Different Forms of Teaching. *International Journal of Instruction*, 11(3), 219-232. https://doi.org/10.12973/iji.2018.11316a

Coles, A. and Sinclair, N. (2017). Re-Thinking Place Value: From Metaphor to Metonym. *For the Learning of Mathematics*, 37(1), 6-12.

Davis, B. (2021). *What are Examples of Kinesthetic Learning? – MV Organizing*. Www.mvorganizing.org. https://www.mvorganizing.org/what-are-examples-of-kinesthetic-learning/

Davis, J. F. and Others, A. (1988). On Matching Teaching Approach with Student Learning Style: Are We Asking the Right Question? In *ERIC*. ERIC. https://eric.ed.gov/?id=ED303859

Disney, A. and Eisenreich, H. (2018). Deepening Place Value Understanding in K-2 Through Explanation and Justification. *Proceedings of the Interdisciplinary STEM Teaching and Learning Conference*, *2*(1). https://doi.org/10.20429/stem.2018.020109

Everything You Need To Know About The Steiner Approach. (2018). CHILD Magazines. https://www.childmags.com.au/education-the-steiner-approach/

Fernández-Méndez, L. M., Contreras, M. J., Mammarella, I. C., Feraco, T. and Meneghetti, C. (2020). Mathematical Achievement: the Role of Spatial and Motor Skills in 6–8 Year-Old Children. *PeerJ*, *8*, e10095. https://doi.org/10.7717/peerj.10095

Herzog, M., Ehlert, A. and Fritz, A. (2019). Development of a Sustainable Place Value Understanding. In *International Handbook of Mathematical Learning Difficulties* (pp. 561–579). https://www.researchgate.net/publication/330875015_Development_of_a_Sustainable_Place_Value_Understanding

Hraste, M., De Giorgio, A., Jelaska, P. M., Padulo, J. and Graniæ, I. (2018). When Mathematics Meets Physical Activity in the School-Aged Child: The Effect of an Integrated Motor and Cognitive Approach to Learning Geometry. *PLoS ONE*, 13(8). https://doi.org/10.1371/journal.pone.0196024

Huang, E. Y., Lin, S. W. and Huang, T. K. (2012). What Type of Learning Style Leads to Online Participation in the Mixed-Mode e-learning Environment? A Study of Software Usage Instruction. *Computers & Education*, 58(1), 338–349. https://doi.org/10.1016/j.compedu.2011.08.003

Kim, D. and Li, M. (2020). Digital Storytelling: Facilitating Learning and Identity Development. *Journal of Computers in Education*, 8. https://doi.org/10.1007/s40692-020-00170-9

Kinesthesia and Proprioception. (n.d.). Pressbooks.umn.edu. https://pressbooks.umn.edu/sensationandperception/chapter/kinesthesia-and-prorioception-draft/

Kinesthetic Perception. (n.d.). Bonnie Terry Learning. https://bonnieterrylearning.com/research/learning-styles/kinesthetic-perception/

Lambert, K. and Moeller, K. (2019). Place-Value Computation in Children with Mathematics Difficulties. *Journal of Experimental Child Psychology*, 178, 214–225. https://doi.org/10.1016/j.jecp.2018.09.008

Lemonidis, C. and Kaiafa, I. (2019). The Effect of Using Storytelling Strategy on Students' Performance in Fractions. *Journal of Education and Learning*, 8(2), 165. https://doi.org/10.5539/jel.v8n2p165

Lindt, S. F. and Miller, S. C. (2017). *Movement and Learning in Elementary School*. Kappanonline.org. http://kappanonline.org/lindt-miller-movement-learning-elementary-school-physical-activity/

Logsdon, A. (2008). *Bodily Kinesthetic Physical Learning Style Characteristics*. Verywell Family; Verywellfamily. https://www.verywellfamily.com/kinesthetic-learner-characteristics-2162776

MacDonald, B. L., Westenskow, A., Moyer-Packenham, P. S. and Child, B. (2018). Components of Place Value Understanding: Targeting Mathematical Difficulties When Providing Interventions. *School Science and Mathematics*, 118(1-2), 17-29. https://doi.org/10.1111/ssm.12258

Marenus, M. (2020). Gardner's Theory of Multiple Intelligences. *Simply Psychology*. https://www.simplypsychology.org/multiple-intelligences.html

Mavlonova, U. K., Abulova, Z. Z. and Kodirov, D. K. (2019). Role Play as a Method of Developing Speaking Skill. *Scientific Reports of Bukhara State University*, 3(1), 253-260. https://doi.org/10.52297/2181-1466/2019/3/1/13

Mendes, A. S., Silva, L. A., Blas, H. S. S., de La Iglesia, D. H., Encinas, F. G., Leithardt, V. R. Q. and González, G. V. (2021). Physical Movement Helps Learning: Teaching Using Tracking Objects with Depth Camera. *Advances in Intelligent Systems and Computing*, 183-193. https://doi.org/10.1007/978-3-030-72654-6_18

Miller, J. (2002). *Examining the Interplay between Constructivism and Different Learning Styles*. https://www.stat.auckland.ac.nz/~iase/publications/1/8a4_mill.pdf

Miller, J. A. (1998). Enhancement of Achievement and Attitudes through Individualized Learning-style Presentations of Two Allied Health Courses. *Journal of Allied Health*, 27(3), 150-156. https://www.learntechlib.org/p/86006/

Myers, B. and Dyer, J. (2006). The Influence Of Student Learning Style on Critical Thinking Skill. *Journal of Agricultural Education*, 47(1), 43-52. https://doi.org/10.5032/jae.2006.01043

Nancekivell, S. (2019). Belief in Learning Styles Myth May Be Detrimental. *Https://Www.apa.org*. https://www.apa.org/news/press/releases/2019/05/learning-styles-myth

Nurlaela, L., Samani, M., Asto, I. G. P. and Wibawa, S. C. (2018). The Effect of Thematic Learning Model, Learning Style, and Reading Ability on the Students' Learning Outcomes. *IOP Conference Series: Materials Science and Engineering*, *296*, 012039. https://doi.org/10.1088/1757-899x/296/1/012039

Özpinar, Ý., Gökçe, S. and Yenmez, A. A. (2017). Effects of Digital Storytelling in Mathematics Instruction on Academic Achievement and Examination of Teacher-Student Opinions on the Process. *Journal of Education and Training Studies*, *5*(10), 137. https://doi.org/10.11114/jets.v5i10.2595

Pearce, J. and Husbands, C. (2012). What Makes Great Pedagogy? Nine Claims from Research. In *Research Gate*. https://www.researchgate.net/publication/309384091_What_makes_great_pedagogy_Nine_claims_from_research

Peterson, A., Dumont, H., Lafuente, M. and Law, N. (2018). Understanding Innovative Pedagogies: Key Themes to Analyse New Approaches to Teaching and Learning. *Www.oecd-Ilibrary.org*. https://doi.org/10.1787/9f843a6e-en

Pinzon, D., Vega, R., Sanchez, Y. P. and Zheng, B. (2017). Skill Learning from Kinesthetic Feedback. *The American Journal of Surgery*, 214(4), 721–725. https://doi.org/10.1016/j.amjsurg.2016.10.018

Ponzo, S. (2019). *Balancing Interoception and Exteroception: Vestibular and Spatial Contributions to the Bodily Self* [PhD Thesis]. https://uhra.herts.ac.uk/handle/2299/22806

Price, G. E., Dunn, R. and Sanders, W. (1981). Reading Achievment and Learning Style Characteristics. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 54(5), 223-226. https://doi.org/10.1080/00098655.1981.9957163

Proprioception, Nociception, Exteroception, Interoception— What do they all Mean? (2018). Musicians' Health Collective. http://www.musicianshealthcollective.com/blog/2016/4/7/proprioception-nociception-exteroception-interoception-what-do-they-all-mean

Sari, M. H. and Olkun, S. (2021). The Relationships among Number Line Estimations, Mathematics Achievement and Place Value Understanding. *GlobETS: An International Conference on Education, Technology, and Science*. https://doi.org/10.30786/jef.729843

Schnarr, K. (2016). *Differentiated Learning and Bodily-Kinesthetic Intelligence: Connecting Theory and Instruction to Encourage Movement in the Elementary Classroom*. https://tspace.library.utoronto.ca/bitstream/1807/72284/1/Schnarr_Kayla_A_201606_MT_MTRP.pdf

Sharma, G. and Kolb, D. A. (2010). The Learning Flexibility Index: Assessing Contextual Flexibility in Learning Style. In S. Rayner & E. Cools (Eds.), *Style Differences in Cognition, Learning, and Management*. Routledge. https://www.taylorfrancis.com/books/edit/10.4324/9780203841853/style-differences-cognition-learning-management-stephen-rayner-eva-cools?refId=2ce6b423-b8cf-41ab-a51f-48beee53f8a5&context=ubx

Simecek, K. and Rumbold, K. (2016). The Uses of Poetry. *Changing English*, 23(4), 309-313. https://doi.org/10.1080/1358684x.2016.1230300

Sinha, K. (2014). *Kinesthetic Learning: Moving Toward a New Model for Education*. Edutopia; George Lucas Educational Foundation. https://www.edutopia.org/blog/kinesthetic-learning-new-model-education-kirin-sinha

Somakim, Darmawijoyo, Eliyati, N. and Yulianita. (2019). Design of mathematics learning by using role playing to investigate the self-efficacy ability. *Journal of Physics: Conference Series*, *1166*, 012034. https://doi.org/10.1088/1742-6596/1166/1/012034

Spainhour, K. (2020). *Engage Kinesthetic Learners With a Multisensory Approach | n2y Blog*. N2y. https://www.n2y.com/blog/multisensory-approach-for-kinesthetic-learners/

Steiner Waldorf Schools Fellowship. (2019). *What is Steiner Education?* Steinerwaldorf.org. https://www.steinerwaldorf.org/steiner-education/what-is-steiner-education/

Stevens-Smith, D. (2004). Movement and Learning: A Valuable Connection. *Strategies*, 18(1), 10-11. https://doi.org/10.1080/08924562.2004.10591106

The Physical (Bodily-Kinesthetic) Learning Style. (2019). Learning-Styles-Online.com. https://www.learning-styles-online.com/style/physical-bodily-kinesthetic/

Vizeshfar, F. and Torabizadeh, C. (2018). The Effect of Teaching Based on Dominant Learning Style on Nursing Students' Academic Achievement. *Nurse Education in Practice*, *28*, 103-108. https://doi.org/10.1016/j.nepr.2017.10.013

Walters, L., Green, M., Goldsby, D. and Parker, D. (2018). Digital Storytelling as a Problem-Solving Strategy in Mathematics Teacher Education: How Making a Math-eo Engages and Excites 21st Century Students. *International Journal of Technology in Education and Science*, 2(1), 1-16. https://www.learntechlib.org/p/207279/

Wan, S. and Niu, Z. (2018). An E-learning Recommendation Approach Based on the Self-organization of Learning Resource. *Knowledge-Based Systems*, 160, 71-87. https://doi.org/10.1016/j.knosys.2018.06.014

Who is Charlotte Mason? (n.d.). Charlotte Mason Institute. https://charlottemasoninstitute.org/who-is-charlotte-mason/

Willingham, D. T. (2013). *Do Visual, Auditory, and Kinesthetic Learners Need Visual, Auditory, and Kinesthetic Instruction?* Reading Rockets. https://www.readingrockets.org/article/do-visual-auditory-and-kinesthetic-learners-need-visual-auditory-and-kinesthetic-instruction

Yulianti, E., Prof, M. and Widyaningsih, H. (2019). Kinesthetic Perception, Physical Activity and on-Task Behavior in Thematic Learning. *IAFOR Journal of Psychology & the Behavioral Sciences*. https://www.researchgate.net/publication/336935335_Kinesthetic_Perception_Physical_Activity_and_on-Task_Behavior_in_Thematic_Learning

Zacharis, N. Z. (2011). The Effect of Learning Style on Preference for Web-Based Courses and Learning Outcomes. *British Journal of Educational Technology*, 42(5), 790-800. https://doi.org/10.1111/j.1467-8535.2010.01104.x

Appendix

The following activity follows evidence-based methods and is included as a proposed lesson for a class of learners. Poetry is an important tool in the learning process as words lead to exploration and understanding (Simecek and Rumbold, 2016). It serves as a context to practice specific skills for their grade level. In this activity, poetry is used to narrate incidents in a context using consistent language to promote a sound understanding of the system of place value. Poetry is also correlated to self-expression and personal development. Roleplay has been an important tool in promoting "merriment" in language learners. Roleplay can be applied to learn subtle aspects of math and science (Mavlonova *et al*., 2019). In a context, role play promotes self-efficacy (Somakim *et al*., 2019). The purpose of using roleplay in connected incidents narrated in a poetry style is to encourage learners to enact the incident and engage them to promote deep learning. A poem is proposed as a learning tool as it uses consistent language to engage learners by connecting numbers as they progress, in a familiar context. The story and context can be easily staged in a learning space, allowing learners to enact the sequence of events narrated in the poem, thereby gaining a stronghold on the place value sense. The following poem is taught either by reciting it or roleplaying for deep learning place value and making purposeful connections.

One Hundred and Five – Is that what We Got

One dot, two dots, three dots, and four dots,

Like the flip of a coin, they landed in my pot,

I smiled with each toss, I loved it lots,

Zero had no dots, and nine had nine,

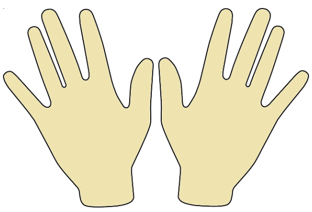
Those were the dots, and I loved it lots.

Then I looked at my hands and counted like the dots,

A dot was to a finger, like a plant is to a pot,

One finger, one dot, two fingers, two dots,

I counted all my fingers, and it was more than nine dots.

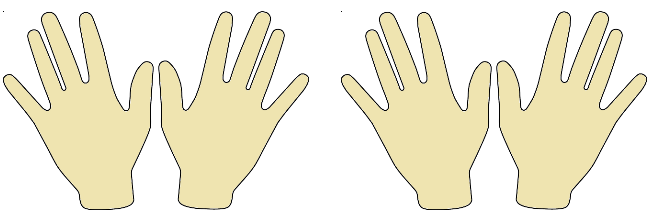


I could do lots more counting with the ten fingers I got,

I smiled ear to ear with an ecstasy of sorts,

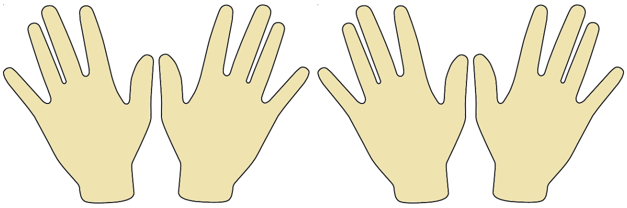
A friend came along, and we waved a lot,

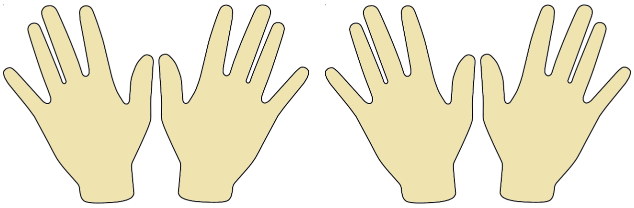
With his two hands, and two mine, let's see how many fingers we got!



Appendix

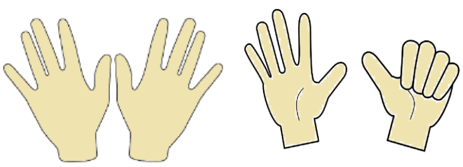
Ten fingers I got, and ten fingers he got,
All children got the same, and we enjoyed a lot,
We counted in the tens, a new number game I taught,
Ten, twenty, thirty, forty – we played, and we rolled, and we fought.





It was time for baseball, only two minutes we got,
Our teenage coach came, he shouted a lot,
"Come inside friends, over here it's really hot",
Those were his words, an instruction of sorts.

"How old are you?", I asked, wondering what age he got,
I am sixteen, he patted me, and I felt like a tiny tot,
Sixteen is ten and six I thought, as I tossed ten coins into my head – my pot,
Then I looked at my ten fingers with an enigma of sorts
And quickly grabbed my friend's hand – all in one shot
"Show me six fingers", I said – he liked my idea a lot,
With me I had ten, and the six that he got,
We knew how to count the age, ten and six in one single shot.

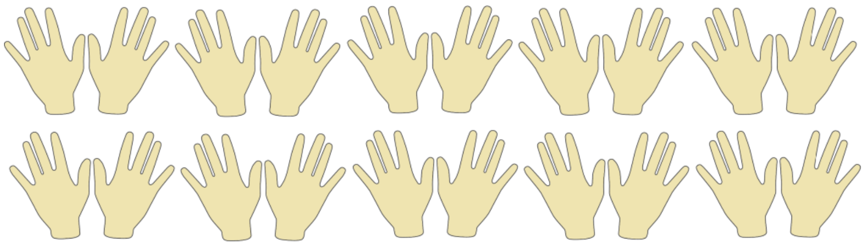


Appendix

Sixteen is no puzzle, nor is seventeen,
eighteen and nineteen, seem like many saplings in a pot.
That's numbers one to twenty, and it's a lot we got,
As numbers made us laugh, we wanted more than what we got.

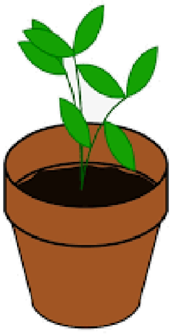
So we walked to the store even when it was hot,
The tag read hundred and five, that's the bill I had got,
I paid the cashier, and he thanked me a lot,
Then I thought and I thought.

I have ten fingers, and my friend with the ten he got.
It gives us twenty, and let's call other friends to see what they got.
Friends after friends, we saw the fingers they got,
Ten, twenty, thirty, forty, and we called more to see what they got.
Nine friends there were – And fingers? Well, ninety they got.
Then one friend came, like a bot,
And so, in this way – hundred fingers we finally got.

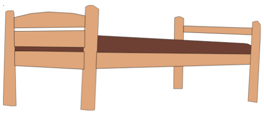


Appendix

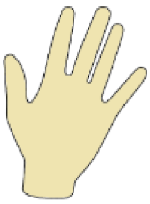
That's the price tag – the price tag also got,
But it had some more, and that looked like a lot,
A lot of work with ten friends that we got,
What is hundred and five then, I thought.
My friends and I thought of a plan – let's see what we got
In a dilemma we swayed, like saplings in a pot.
We needed a plan after hundreds, and we need to think a lot.



Then one friend popped up and flew across the cot
In surprise we gazed as he ran a lot
Then came back to us, feeling tired and hot
What a pleasant surprise, another dear friend he had got



He displayed his fingers and there they were
Five more fingers we finally got
To make it to the numbers in the tag, I thought
A hundred and five – we finally reached in a shot
The best day we had even though it was hot.



Cite this article as: Safia Fatima Mohiuddin (2022). Revisiting the Plausibility of Learning Style Theories with Evidence of Kinesthetic Perception: A Literature Review and Proof of Concept Towards Justifying Differentiated Instruction. *International Journal of Education and Teaching,* 2(1), 29-47. doi: 10.51483/IJEDT.2.1.2022.29-47.