Dance to Learn: A Kinesthetic Approach to Teach Reactivity of Group 1 and 7 Elements in the Periodic Table of Elements

Yiing Yiing Chong[1#,a)], Nelson Cyril[2,b)], Khar Thoe Ng[3,c)]

[1#] Sung Siew Secondary School, Sandakan, Sabah, Malaysia
[2]Pondok Upeh Secondary School, Balik Pulau, Penang, Malaysia
[3]Faculty of Social Science and Liberal Arts (FOSSLA), UCSI university, Kuala Lumpur, Selangor, Malaysia

Author's Emails
[#,a)]corresponding author <cyyatwork@gmail.com>
[b)]*nelson8012@gmail.com*, [c)]*postgradreview@gmail.com*

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Abstract

Purpose- The purpose of this study is to evaluate the effectiveness of a dance-based kinesthetic approach of teaching with improvement of students' scores in explaining the changes in reactivity of Group 1 and 17 elements when going down the groups in the Periodic Table of Elements. The research also seeks to assess students' perceptions of the ease of following and the engagement level of the dance.

Methodology – This study was conducted using Design and Development Research (DDR) approach involving the design of particular lesson undergoing 'specific project phases involving evaluation' of 'product & tool research' of DDR involving 'Engage, Explore, Explain, Elaborate, Evaluate' (5E) lesson exemplar supported by 'constructivist learning theory and teaching-learning research with pre- and post-test implemented' as an instructional system design (ISD) product. Through simple hand movements, this study employs a dance-based kinesthetic approach of teaching integrating 5E instructional model. A sample of 41 students from a science stream class of a secondary school in Sandakan, Sabah, participated in this study. A pre-test was conducted based on the Trial 1 SPM exam on August 18, 2022, followed by a post-test immediately after the dance was introduced on September 21, 2022. A follow-up test was conducted two weeks later to assess the students' ability to retain the concepts. Students were required to state five concepts about the reactivity of Group 1 elements and Group 17 elements, respectively, to obtain a full score of 5. In addition to the quantitative data collected from the pre-test, post-test, and follow-up tests, qualitative data about students' perceptions of the ease of following and engagement level of the dance was also collected.

Findings – The findings of the study showed that the dance-based kinesthetic approach was effective in improving students' scores in stating the reactivity of Group 1 and Group 17 elements in the Periodic Table of Elements. The post-test results revealed that 95.1% of the students achieved a full score of 5 points for both Group 1 and 17 elements, compared to 7.3% during the pre-test. The mean score also increased, from 2.37 to 4.95 for both groups of elements, with an N-gain score of 0.98. This suggests that the dance-based kinesthetic approach is able to improve students' scores significantly. The follow-up tests conducted after two weeks also showed that students were able to maintain their performance with scores of 4.95 for Group 1 elements and 4.85 for Group 17 elements.

Significance and Contribution This study highlights how a kinesthetic approach can positively impact students' learning and retention, providing a valuable contribution to the field of science education based on the 5E instructional model. This study revealed a concrete illustration of the dance-based approach that can be implemented in the classroom, and be used as an alternative tool for teachers.

Keywords: *Dance-based kinesthetic approach; Group 1 and 17 elements; Ease of following; Engagement; Retention; Scores improvement*

Introduction

Based on experience teaching previous batches of students, it was revealed that there was poor performance when these students were asked to state the reactivity of Group 1 elements. The mean score of students was only 2.37 out of 5 points, suggesting that students were not retaining the content taught in science lesson particularly the concept of reactivity of groups they had learned. This prompted the first author to consider a new approach to teaching.

Problem Statement and Rationale

Research supports the idea of using multiple methods to present material in order to cater to different learning styles. According to Howard Gardner, no matter what is the subject, learning materials should be presented in a variety of ways to reach all students considering their multiple intelligences, five of which are ‘Bodily/Kinesthetic’ (BK), ‘Musical/Rhythmical’ (MR), ‘Logical/Mathematical’ (LM), ‘Verbal/Linguistic’ (VL) and ‘Visual/Spatial’ (VS) intelligences (Gardner, 2013; Northern Illinois University Center for Innovative Teaching and Learning, 2020). In recent years, arts have been integrated into science education, such as from ‘Science, Technology, Engineering, Mathematics’ (STEM)(involving especially LM intelligences) to STEAM and STREAM, where "A" denotes "arts" while “R” denotes “reading/writing” (Root-Bernstein & Root-Bernstein, 2011) involving especially BK, MR and VL intelligences (Gardner, 2013).

One form of art that has become increasingly popular, particularly among young people, is dance. Dance is often seen in social media, such as TikTok videos, and is enjoyed by many. Given this popularity, it is reasonable to incorporate dance into science education as a means of engaging students (Begel, García & Wolfman, 2004). This is especially true for preschool and primary school learners, who tend to learn faster through movement (Begel et al., 2004) using their BK and MR intelligences.

However, most teachers are trained to use verbal and visual means as teaching methods for subjects like mathematics, science, or social studies (Beserra et al., 2021). Limited research has explored the integration of dance as a teaching method in science education, particularly in regard to the reactivity of Group 1 and 17 elements. Addressing this gap, this study aims to add new insights to the existing innovative and engaging teaching methods for science education.

Aims and Objectives of Study

The current study explores the effectiveness of a dance-based kinesthetic approach in science education, specifically in the areas of retention, engagement, and improvement of scores. The study aims to provide additional support for the integration of dance in science classrooms to enhance students' learning outcomes combining physical movements with academic content using simple hand movements to enhance students' BK, LM and MR intelligences.

Hence, the Research Objectives of this study are:

1. To investigate the impact of dance on students' scores in stating the reactivity of Group 1 and Group 17 elements in the Periodic Table of Elements.
2. To describe students' perceptions of the ease of following and engagement level of the dance.

Literature Review

Physically Active Lessons (PAL)

Physically active lessons (PAL) are lessons that are partially or wholly taught through movement (Routen & Sherar, 2017). The intervention of physically active lessons (PAL) in the classroom is integrating physical activity into academic lessons (The Community Guide, 2021). Physically active lessons include dancing, running, jumping, or moving the arms. Among the various forms of physically active lessons, the use of dance as an educational tool stands out (Beserra, et al., 2021).

According to a study conducted by Donnelly and Lambourne (2011), physically active academic lessons of moderate intensity were able to improve overall performance on a standardized test of academic achievement by 6% compared to a decrease of 1% for controls. However, most teacher training programs usually focus on verbal and visual means as teaching methodology for subjects like mathematics, science, or social studies but not physically active lessons delivered through dance (Beserra et al., 2021).

Dance in Science Education

A historical recognition published in studies revealed the benefits of using movement in learning. Educational philosophers from Aristotle to Dewey, Whitehead, and Montessori have all encouraged the use of movement in the classroom to enhance student understanding of content, improve classroom behaviour, and develop new forms of assessment (Skoning, 2008).

The use of dance and creative movement as teaching tools in science education provides a unique way to meet the needs of a variety of learners, particularly kinesthetic learners, in a meaningful manner (Skoning, 2008). The Dance Your Ph.D. contest, which was first held in 2008 by Science Magazine and the American Academy for the Advancement of Science, is a demonstration of the innovative use of dance in science education (Myers, 2012). The contest challenged PhD students or holders to explain their research through interpretive dance rather than slides or talking (Career Navigator, 2018). This is to educate the public by making complex theories more accessible and understandable using a kinesthetic approach.

Kinesthetic Approach to Teaching

The kinesthetic approach to teaching highlights the importance of recognizing and accommodating different learning styles among students. The 'Visual, Auditory, Reading/Writing and Kinesthetic' (VARK) learning style model, introduced by Fleming (Prithishkumar & Michael, 2014), categorizes students into four different learning modes which are visual, auditory, reading/writing, and kinesthetic. Visual learners prefer to see information in order to understand it effectively. Auditory learners, on the other hand, learn best through listening and speaking. Reading/writing learners, learn best through written material. Kinesthetic learners learn best through physical activities and hands-on experiences. Studies have shown that kinesthetic and auditory learning styles are commonly preferred among students (Prithishkumar & Michael, 2014). Grant (1985) conducted a study on first-graders and found that using kinesthetic approaches in teaching reading and writing skills, which relied heavily on motor skills and gestures, was not only effective but also more enjoyable for the students. The results showed that the students in the experimental group met or surpassed the students in the control group in all five areas of language/arts tested, and the improvement was attributed to the kinesthetic approach.

These findings may support the integration of kinesthetic approaches in the classroom, as it can cater to the preferences of some students and enhance their understanding as well as retention of the content using instructional system design (ISD) such as the 5E model.

5E Instructional Model

According to Bybee, et al. (2006), the 5E Instructional Model is an effective teaching strategy that has been widely used in science education since the late 1980s. The model is based on five phases: 'Engagement, Exploration, Explanation, Elaboration, and Evaluation' (5Es). Each phase is designed to promote critical thinking, conceptual understanding, and the development of skills in students.

The Engagement phase aims to access students' prior knowledge and stimulate their interest in learning a new concept through the use of activities that promote curiosity with elicitation of prior knowledge. This phase helps to make connections between past and present learning experiences, expose prior misconceptions, and organize students' thinking towards the learning objectives.

The Exploration phase provides students with opportunities to generate new ideas, explore questions and possibilities, as well as conduct a preliminary investigation based on their prior knowledge. This phase helps to identify current concepts, processes, and skills with facilitation of conceptual change.

The Explanation phase focuses students' attention on a particular aspect of their engagement and exploring experiences, providing opportunities for them to demonstrate their understanding of a concept, process, or skill. This phase also involves the introduction of new information by the teacher or the curriculum, which guides students towards a deeper understanding of the concept.

The Elaboration phase challenges and extends students' conceptual understanding as well as skills through new experiences. This phase allows students to develop a deeper and broader understanding, more information, as well as sufficient skills.

Finally, the Evaluation phase encourages students to assess their understanding and abilities as well as provides opportunities for teachers to evaluate their progress.

The 5E Instructional Model plays a critical role in the curriculum development process and the implementation of curricular materials in science classrooms. According to Bybee et al. (2006), the model can be used to design entire programs, specific units, or individual lessons, making it a versatile and effective teaching strategy.

In conclusion, the 5E Instructional Model is a well-established teaching strategy that has proven to be effective in promoting critical thinking, conceptual understanding, and the development of skills in science education. This model provides a structured and engaging approach to teaching, which has been widely adopted and continues to be used in many science classrooms.

Methodology

Research Design

This study was conducted using Design and Development Research (DDR) approach involving the design of particular lesson undergoing 'specific project phases involving evaluation' of 'product & tool research' of DDR (Richey & Klein, 2007, p. 8) involving 'Engage, Explore, Explain, Elaborate, Evaluate' (5E) lesson exemplar as an instructional system design (ISD) product (Ragan & Smith, 2004 in Richey & Klein, 2007, p. 27). The 5E instructional strategies supported by constructivist learning theories and teaching-learning research were implemented with management of the overall design process including evaluation activities using pre- and post-test administered before and after the lesson (Ragan & Smith, 2004 in Richey & Klein, 2014).

Participants

The study utilized a convenience sampling approach and involved 41 secondary school students from a science stream class of SM Sung Siew in Sandakan, Sabah. SM Sung Siew is a government school established in 1907, with a student population of 1328. The study participants involved a mix of male and female students, with 19 males and 22 females. Convenience sampling was employed as the researcher was the teacher for the selected class.

All the students selected were from a streamed class, indicating similar overall academic achievement. However, there were variations in their achievements in the Chemistry subject and also in their understanding of the reactivity of Group 1 and Group 17 elements, as demonstrated by their scores in the SPM Trial 1 exam.

The intervention involved the integration of dance as a teaching method for the reactivity of Group 1 and Group 17 elements. As the teacher had no prior dance training, simple hand movements were developed to teach the concepts. The intervention was implemented during regular class time.

The pretest scores were obtained from the SPM Trial 1 exam, specifically for the question related to stating the reactivity of Group 1 elements. The posttest scores were collected a day after the introduction of the dance activity and consisted of two separate scores: one for the reactivity of Group 1 elements and another for the reactivity of Group 17 elements. Each component had a maximum score of 5 points, as it involved the understanding of five different concepts. Both the pretest and posttest questions assessed the students' understanding of the same concepts regarding the reactivity of Group 1 elements.

A follow-up test was conducted two weeks after the intervention to assess the students' long-term retention of the concepts. Similar to the posttest, the follow-up test included separate scores for the reactivity of Group 1 and Group 17 elements using the 5E model lesson plan.

The lesson plan was designed to incorporate activities and assessments in each of the five phases to ensure that students were actively participating in their learning and making meaningful connections to the dance content.

5E LESSON PLAN

SIMPLE HAND MOVEMENTS OR DANCE TO TEACH THE REACTIVITY OF GROUP 1 AND 17 ELEMENTS

School	:	SM Sung Siew (CF)
Subject	:	Chemistry
Grade	:	Form 5
Topic	:	Chapter 4: The Periodic Table of Elements (Form 4 syllabus)
Sub Topic	:	4.4 Elements in Group 1 4.5 Elements in Group 17
Date/Day	:	21 September 2022 (Wednesday)
Time Allocation	:	60 Minutes
Venue	:	Class 5E
No. of students	:	41

A. Basic Competence of learning

Objective of learning:

4.4.3 Generalise the changes in the reactivity of elements when going down Group 1.
4.5.3 Generalise the changes in the reactivity of elements when going down Group 17.

Outcomes of learning:

Pupils are able to:
(a) state the changes in the reactivity of elements when going down Group 1.
(b) state the changes in the reactivity of elements when going down Group 17.

B. Learning Model/Learning Strategy

- Teaching and learning model / Strategy : 5E learning model, simple hand movements or dance
- Scientific skills : Communicating, Observing
- Prior knowledge : Investigation on the reactivity of Group 1 and 17 elements in water or oxygen or both

C. Learning Activities

Phase (Duration)	Teacher Activity	Student Activity
Engage (5 minutes)	Teacher wears black and pink attire (Figure 1) to resemble Blackpink (famous South Korean girl group artists)(Figure 2). This will serve as a visual cue for the students and help to get them in the right mindset for learning through movement as well as dance. Teacher greets all the students and asks if all of them are ready for a great dance like "Blackpink." Figure 1 Teacher in black & pink attire  Figure 2 The Korean girl group called Blackpink 	Students get ready for the lesson (Figure 3). Figure 3 The students prepared themselves for the lesson 
Explore (15 minutes)	Teacher demonstrates the structured hand movements or dance to students (Figure 4).	Students learn the dance moves step by step (Figure 5)

	Figure 4 Teacher led the students in hand movements or dance 	Figure 5 Students gradually mastered the dance moves 
Explain (15 minutes)	Teacher explains each movement while reciting the concepts (Figure 6). Figure 6 The teacher, along with a few chosen students, elaborated on each movement while reiterating the key concepts  Explanation begins with **Group 1** elements. Concept 1-Atomic size increases when going down the group. Concept 2-Distance between nucleus and valence electron becomes further. Concept 3-Forces of attraction between nucleus and valence electron becomes weaker. Concept 4-Easier to donate electrons. Concept 5-Reactivity increases when going down the group.	Students follow the movements while reciting the concepts after teacher (Figure 7). Figure 7 The students followed the movements while reiterating the key concepts after teacher demonstrated them  **Group 1** elements: Concept 1-Atomic size increases when going down the group. Concept 2-Distance between nucleus and valence electron becomes further. Concept 3-Forces of attraction between nucleus and valence electron becomes weaker. Concept 4-Easier to donate electrons. Concept 5-Reactivity increases when going down the group.
Elaborate (15 minutes)	Teacher asks students to relate the concepts they have learned with **Group 17** elements.	Students respond and give their answers.

	Concept 1-Atomic size increases when going down the group. Concept 2-Distance between nucleus and valence electron becomes further. Concept 3-Forces of attraction between nucleus and valence electron becomes weaker. **Concept 4-More difficult to receive electrons.** **Concept 5-Reactivity decreases when going down the group.** Teacher shows students the movements for Group 17 elements (Figure 8) and **emphasizes Concepts 4 and 5**, as they are **different** from Group 1 elements. Figure 8 Teacher demonstrated the movements for Group 17 elements and emphasized Concepts 4 and 5, as they differed from Group 1 elements 	**Group 17** elements: Concept 1-Atomic size increases when going down the group. Concept 2-Distance between nucleus and valence electron becomes further. Concept 3-Forces of attraction between nucleus and valence electron becomes weaker. Concept 4-More difficult to receive electrons. Concept 5-Reactivity decreases when going down the group. Students follow the movements while reciting the concepts after teacher (Figure 9). Figure 9 The students followed the movements and recited the concepts after teacher demonstrated them 
Evaluate (10 minutes)	Teacher evaluates students' understanding by asking them to write the trend of changes of reactivity for Group 1 elements and Group 17 elements. Teacher asks students to give their feedback on these questions: 1. Is this movement/ dance easy to	Students write the changes of reactivity for Group 1 elements and Group 17 elements on papers.

	follow? Yes/No 2. Is it engaging? Yes/No 3. Any suggestions to make it better? (open-ended response) 4. Which is better for you? ☐ Dance only ☐ Dance and saying it aloud (reciting) ☐ Dance and sing	

Analysis

To address Objective 1 of this study i.e., to evaluate the effectiveness of a dance-based kinesthetic approach to improve students' scores, the summary of data is illustrated in Table 1.

Table 1 Students' Scores for the Pretest, Posttest, and Follow-up Test

Score	Pretest for Group 1 elements during SPM Trial 1 exam 18 August 2022 (%)	Posttest after the introducing the dance on 21 September 2022		Follow-up test on 5 October 2022	
		Group 1 elements (%)	Group 17 elements (%)	Group 1 elements (%)	Group 17 elements (%)
5	7.3	95.1	95.1	94.9	87.2
4	14.6	4.9	4.9	5.1	10.3
3	22.0	0	0	0	2.6
2	31.7	0	0	0	0
1	12.2	0	0	0	0
0	12.2	0	0	0	0

According to the posttest, 95.1% of students obtained a full score of 5 points for both Group 1 and 17 items, compared to 7.3% during the pre-test. The mean score increased from 2.37 to 4.95 for both groups of elements, with an N-gain score of 0.98. This suggests that the dance-based kinesthetic approach is able to improve students' scores significantly. The follow-up tests conducted after two weeks also showed that students were able to maintain their performance with scores of 4.95 for Group 1 elements and 4.85 for Group 17 elements (Table 2).

Table 2 The Mean Scores of Students for the Pretest, Posttest, and Follow-up Test

Pretest for Group 1 elements during SPM Trial 1 exam 18 August 2022 (Mean score)	Posttest after the introducing the dance on 21 September 2022		Follow-up test on 5 October 2022	
	Group 1 elements (Mean score)	Group 17 elements (Mean score)	Group 1 elements (Mean score)	Group 17 elements (Mean score)
2.37	4.95	4.95	4.95	4.85

Next, students were requested to write on what they have learned as presented in the following Figure 10 and Figure 11.

Figure 10 Ability of students to state the change of reactivity of Group 1 elements

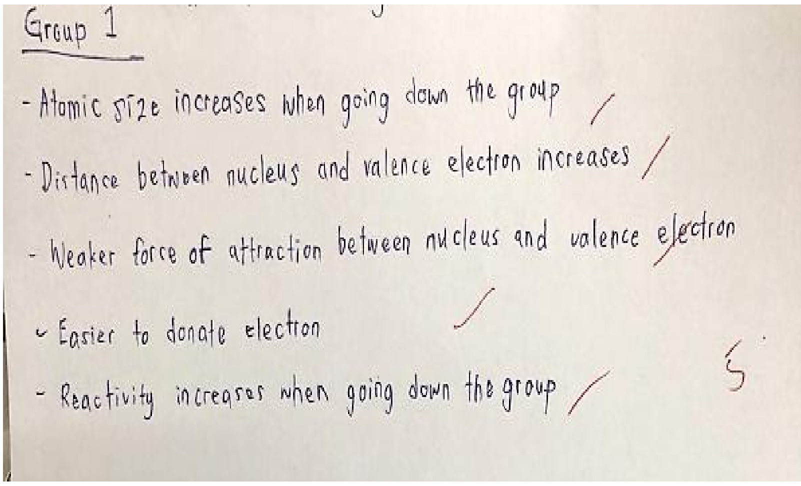
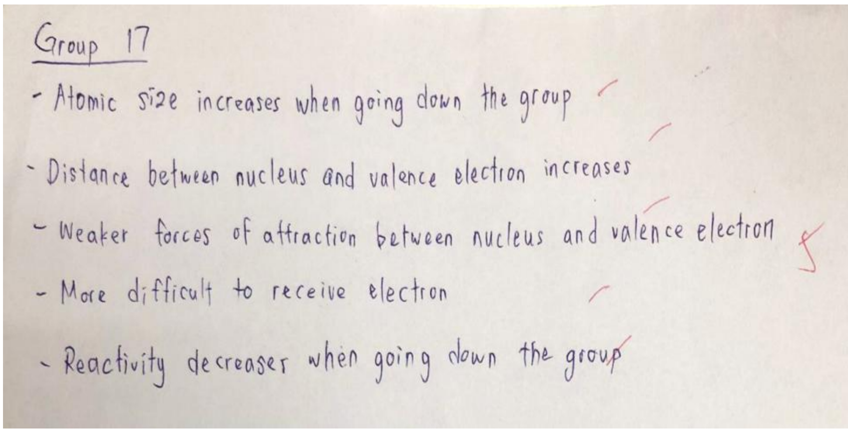


Figure 11 Ability of students to state the change of reactivity of Group 17 elements



The retention rate was remarkably high at 100% for Group 1 elements and 98.0% for Group 17 elements suggesting students had a high rate of grasping the concept of the topic learnt.

In response to Research Objective 2 of this study to seek students' perceptions as described by students A and B, the findings are illustrated in the following Figure 12 and Figure 13.

Figure 12 Student A feedback on the dance

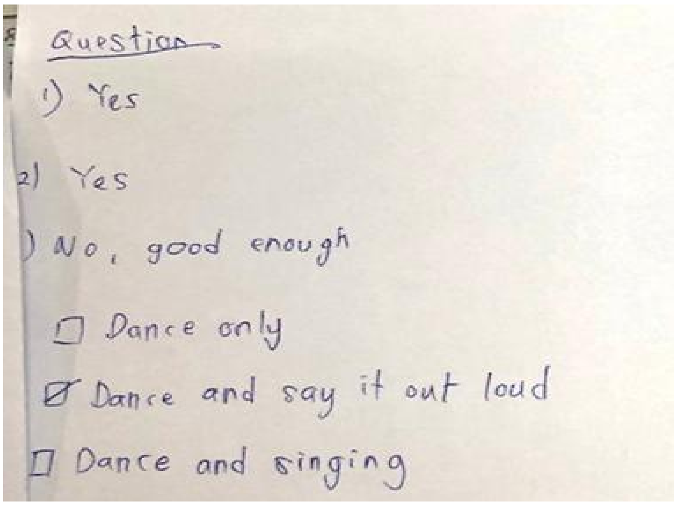
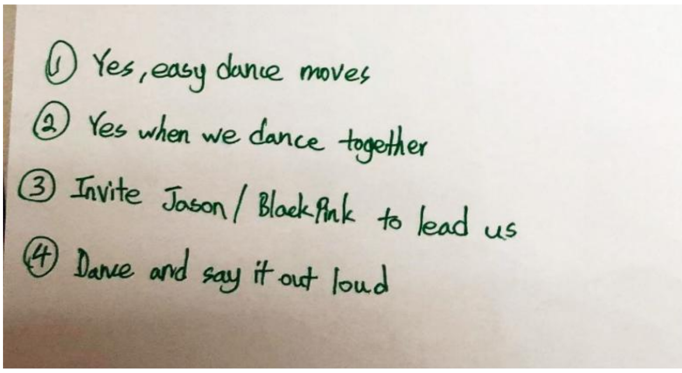


Figure 12

Figure 13 Student B feedback on the dance



Students A and B feedback clearly depicted that students found the activity was educational and a and attained the learning outcomes set.

Alternatively, the number of student respondents providing feedback on each question was also gathered and presented in Table 3.

Table 3 Students' Perceptions of the Dance (N=47)

Item to be responded	Number of respondents stating 'Yes'	Percentage (%)
Easy to follow	38	92.7
Engaging	36	87.8

Based on this study, majority of the students reported that the kinesthetic approach was easy to follow (92.7%) and engaging (87.8%).

The analysis of feedback received revealed that generally students felt learning reactivity of elements using dance 'easy to follow' and 'say it' loud assisted them to enhance their grasping of the concept.

Discussion

To answer the first Research Objective, the posttest scores of this study supported the effectiveness of the dance-based kinesthetic approach in teaching and learning the reactivity of Group 1 and Group 17 elements. Besides, most of the students found that the dance was easy to follow and engaging. Furthermore, students were able to retain the concepts taught through dance-based instruction. These findings concur with the study by Donnelly and Lambourne (2011) who discovered that physically active academic lessons were able to increase the overall performance of an academic achievement by 6% compared to a decrease of 1% if taught with the conventional method.

The findings were also found to be aligned with the study by Howard Gardner who discovered that learning materials should be presented in a variety of ways to reach all students' learning styles (Gardner, 2013; Northern Illinois University Center for Innovative Teaching and Learning, 2020). Therefore, incorporating kinesthetic elements, such as dance, can enhance the learning experience for kinesthetic learners. The use of dance in science education also resonates with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) movement, which emphasizes the integration of arts in STEM subjects (Root-Bernstein & Root-Bernstein, 2011). These theoretical perspectives provide a foundation for understanding the positive impact of the dance-based kinesthetic approach in this study.

Moreover, the findings of this study contribute to the discourse on engaging a different teaching method. Traditional lecture-based teaching methods often struggle to capture and maintain students' attention, leading to limited understanding and retention of concepts. Incorporating dance as a form of active learning, this study demonstrates that students' engagement and understanding of the reactivity of Group 1 and Group 17 elements significantly improved. This supports the growing recognition that integrating arts-based activities, such as dance, can enhance student learning outcomes and foster a deeper understanding of scientific concepts.

This study provides evidence to support the integration of dance into the curriculum. Hence curriculum developers can consider incorporating kinesthetic activities, such as dance, to promote students' achievement scores and engagement.

Conclusion

Summary and Implications

In a nutshell, the dance-based kinesthetic approach offers a fun and active way of learning that aims to improve students' scores, engagement, and retention of information.

By incorporating dance into the classroom, students can be more engaged and motivated in their learning, hence may lead to a deeper understanding of the concepts. The structured nature of the dance helps students to remember the concepts and their order more effectively. Additionally, this approach is convenient for teachers as it requires minimal time to prepare and no material preparation. Overall, the use of dance as an instructional tool provides a beneficial and efficient teaching method that enhances student learning outcomes.

Limitations and Recommendations

Due to constraints faced in terms of time and other requirements needed to prepare students adequately for public examination, the first author only managed to pilot test her draft lesson plan developed through 5E instructional model using Design and Development Research approach (Richey & Klein, 2014).

But the preliminary findings of this study could serve as baseline data for the planning of bigger scale quasi-experimental study involving other samples with all prerequisites are fulfilled such as ensuring comparability of the samples using statistical analysis. The approach introduced in this study has been shown to be effective in increasing students' engagement, improving their scores, and helping them retain the information longer. It is also efficient for busy teachers, as it requires minimal time to prepare and no material preparation. Based on the results of this study, it is recommended that schools and teachers may consider incorporating the kinesthetic approach into their teaching methods.

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References

Begel, A., García, D. & Wolfman, S. (2004). Kinesthetic learning in the classroom. ACM SIGCSE Bulletin, 36, 183-184. https://doi.org/10.1145/1028174.971367

Beserra, V., Nussbaum, M., Navarrete, M., & Alvares, D. (2021). Teaching through dance: An opportunity to introduce physically active academic lessons. *Teaching and Teacher Education*, 106, 103450. https://doi.org/10.1016/j.tate.2021.103430

Bybee, R. W., Taylor, J. A., Gardner, A., Scotter, P. V., Carlson, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications*. BSCS.

Career Navigator. (2018). *[GSAS] Announcing the 11th Annual AAAS Dance Your PhD Contest!* https://careernavigator.gradeducation.hms.harvard.edu/news/gsas-announcing-11th-annual-aaas-dance-your-phd-contest

Donnelly, J. & Lambourne, K. (2011). Classroom-based physical activity, cognition, and academic achievement. *Preventive medicine.* 52 Suppl 1. S36-42. https://doi.org/10.1016/j.ypmed.2011.01.021

Gardner, H. (2013). Frequently asked questions—Multiple intelligences and related educational topics. https://howardgardner01.files.wordpress.com/2012/06/faq_march2013.pdf

Grant, S. M. (1985). A kinesthetic approach to teaching: Building a foundation for learning. *Journal of Learning Disabilities*, 18(8), 455-462. https://doi.org/10.1177/002221948501800803

Myers, N. (2012). Dance Your PhD: Embodied Animations, Body Experiments, and the Affective Entanglements of Life Science Research. *Body & Society*, 18(1), 151–189. https://doi.org/10.1177/1357034X11430965

Northern Illinois University Center for Innovative Teaching and Learning. (2020). *Howard Gardner's theory of multiple intelligences.* https://www.niu.edu/citl/resources/guides/instructional-guide/gardners-theory-of-multiple-intelligences.shtml

Prithishkumar, I. J & Michael, S. A. (2014). Understanding your student: using the VARK model. *J Postgrad Med.* , 60(2), 183-6. https://pubmed.ncbi.nlm.nih.gov/24823519/

Richey, R.C. & Klein, J.D. (2007). *Design and development research: Methods, strategies and issues*. Lawrence Erlbaum Associates, Inc. https://doi.org/10.4324/9780203826034 file:///C:/Users/User/Downloads/9780203826034_previewpdf.pdf

Richey, R.C. & Klein, J.D. (2014). *Design and development research: Methods, strategies and issues*. New York: Routledge. https://www.researchgate.net/publication/347493089_Design_and_Development_Research_Methods_Strategies_and_Issues

Root-Bernstein, R., & Root-Bernstein, M. (2011). *Turning STEM into STREAM: Writing as an Essential Component of Science Education*. National Writing Project. Berkeley.

Routen, A. & Sherar, L. (2017). *Active lessons can boost children's learning and health.* The conversation. https://theconversation.com/active-lessons-can-boost-childrens-learning-and-health-72240

Skoning, S. N. (2008). Movement in dance in the inclusive classroom. *TEACHING Exceptional Children Plus*, 4(6) Article 2. http://escholarship.bc.edu/education/tecplus/vol4/iss6/art2

The Community Guide. *Physical Activity: Classroom-based Physically Active Lesson Interventions*. (2021). https://www.thecommunityguide.org/findings/physical-activity-classroom-based-physically-active-lesson-interventions.html.