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Research Article

EFFECTS OF TEACHING USING A 'DANCE' ANALOGY ON SECONDARY SCHOOL PHYSICS STUDENTS' CONCEPTUALIZATION OF HEAT CONCEPTS

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ABSTRACT

Research in concept learning in science reveals that analogy is an effective instructional strategy in facilitating conceptual change within a constructivist paradigm. However in most non-Western contexts most of the analogies used by researchers have merely replicated analogical models fashioned for teaching science within Western contexts. The aim of this research was to investigate the effect of analogies derived from learners' socio-cultural environment on concept learning in physics. Specifically, the study used a traditional African dance analogy to teach aspects of physical heat concepts. The results were compared with those of teaching the concepts using the conventional methods. Using the Solomon Four Non-equivalent Control Group Design, data were collected from Form I (Grade 9) students in four secondary schools in Nyandarua County, Kenya. The schools were randomly assigned to the four groups of the research design. The instrument was a Heat Concepts Test (HCT) in two equivalent forms one for pre-test and the other for post-test. The two were systematically assessed for validity and reliability by involving experts in Science Education and through pilot study. Hypotheses were tested using student's t-test and ANOVA at an alpha level of 0.05. Results show that teaching using the traditional dance analogy led to higher conceptual gains of physical heat concepts compared to teaching using conventional methods. Analogy teaching also facilitated reduction of more of students' misconceptions of physical heat concepts compared to conventional teaching methods. Based on these findings the study recommends that teachers should often consider students' socio-cultural knowledge as the basis for selecting and designing analogies to facilitate conceptual change in teaching abstract science concepts.

INTRODUCTION

An important component of science learning is mastery of scientific concepts.Understanding scientific concepts is paramount for accurate interpretation and explanation of observed natural phenomena (Njuguna, 2012). Physics a discipline has been defined as the branch of the natural sciences that seeks to understand the principles and laws that govern the universe (Zhaoyao, 2002). Indeed one of the aims of teaching physics in secondary schools in Kenya is promotion of students' scientific knowledge about the physical world (Okere, 1996). Many topics in physics are related to or based on the structure of matter. Matter is composed of millions of sub-microscopic particles (Nelkon and Parker 2000). Their behavior explains most of the observed macroscopic properties of matter studied in physics. Physics therefore proves a difficult subject for many students.

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The physics curriculum incorporates many abstract concepts which are central to further learning, both in physics and other science subjects (Taber, 2002). The abstract nature of physics along with other content learning difficulties, for example the mathematical nature of physics, means that physics classes require a high–level skill set (Okere, 1996). Research results indicate that students in secondary schools in Kenya and equivalent grades worldwide have difficulties understanding abstract physics concepts (Kaboro, 2014). The results give increasing evidence of existence of misconceptions in students' understanding of fundamental concepts in physics (Driver, 1995; Kaboro, 2003; Okere, 1991; Pfundt and Duit, 1994; Zietsman and Naidoo, 1997). Persistence of these misconceptions even after formal instruction gives credence the fact that the classroom experiences provided to the learners are limited and inappropriate to facilitate effective conceptual change (Barkerand Millar, 2000; Hand and Keys, 1999). The topic of 'heat' forms an important part of the science curriculum in primary schools and physics curriculum in secondary schools in Kenya (KIE, 2012). An essential characteristic of the topic is the interplay between the macroscopic properties and the microscopic behaviour of particles of matter (Sirhan, 2007). This aspect of the topic presents difficulties to learners.Kaboro (2003) documented a range of misconceptions on the topic held by students in Form I and Form III (grades 9 and 11 respectively) in secondary schools and university second year Bachelor of Education (B.Ed) and Bachelor of Science (B.Sc) students. This confirmed earlier concerns by Okere (1991) that students' misconceptions persist well into university education. Explanation of physical phenomena associated with heat, for example temperature, thermal expansion, heat transfer and change of state is grounded on particulate nature and kinetic theory of matter (Barkheimer, Anderson andSpees, 2010). The theory explains the composition and the structure of matter the behaviour of particles of matter under different conditions and the processes that arise when different matter interact (Feynman, 1995). This abstract nature of the theory makes its teaching and learning in schools challenging (Bar andGalili, 1994; Hewsonand Hamlyn, 1984).

A needs assessment survey by the centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) in Nyandarua County, Kenya in 2009 identified 'heat' as one of the topics that presented difficulties in physics education (CEMASTEA, 2010). Teachers explained that due to the abstractness of particulate nature and kinetic theory of matter which is based on the behaviour of unobservable particles of matter, there were no readily available practical activities to facilitate students' conceptualization. Integration of information communication technology in teaching and learning in most rural schools in Kenya is limited due to inadequate equipment with computers (Waithanji, 2014). Therefore computer simulation of particulate nature and kinetic theory of matter during instruction is limited. According to CEMASTEA most teachers have resorted to explaining observable physical phenomena associated with heating and cooling using theoretical approaches. These approaches are incapable of facilitating meaningful conceptual change (Driver, 1995).

Research has shown that meaningful learning takes place through connecting new information to prior knowledge (Anderson, 1993; Driver, 1989; Hand and Keys, 1999). This contemporary view of learning is structured around the tenets of a constructivist epistemology. Constructivism advances the view that learners construct new knowledge by utilizing their previously acquired knowledge (Kuhn, 1996). Researchers agree that the prior knowledge that learners bring into the science classrooms has a considerable impact on their subsequent learning (Duit and Teagust, 1998; Vosniadou, 2003). Learners should therefore be facilitated to connect new concepts to ideas with which they are already familiar (Kaboro, 2014). This way, learning becomes meaningful and continuous (Leach and Scott, 2003). The consequence of the foregoing information is that the science teacher should identify suitable experiences familiar to the learner to act as an anchorage in learning of new science concepts (Clement and Brown, 1989). Analogy teaching is a general teaching–learning strategy where the learner is guided to conceptualize a new concept by drawing parallels between aspects of the concept and those of a familiar phenomenon with which it shares common traits (Glynn, 1991).

Through analogical reasoning the learner is able to construct a complete set of associations between features of specific concepts (Tsai, 1999). The underlying efficacy of a teaching analogy to explain a concept depends on the number of features that can be compared between the familiar phenomenon and the new concept, the similarity of the shared attributes and their conceptual significance and the extent to which students are familiar with the familiar phenomenon (Fast, 1999). Analogy teaching has been found useful in providing visualization of abstract concepts (Lakoge, JegedeandOyebanj, 2007); overcoming misconceptions (Kigo 2006), and motivating learners (Shihusa and Keraro, 2009). However, in use of analogies it is important to consider learners background so that the selected analogy is familiar to them. Review of literature established that most of the studies on analogies within non-Western classrooms merely replicated analogical models fashioned for teaching science in Western classrooms. The analogy used in this study was selected based on the assumption that a traditional dance is a familiar social phenomenon to learners within the African context.

Purpose of the Study

The aim of the study was to investigate the effect of teaching using a 'traditional dance' analogy on students' conceptualization of physical heat concepts. The effect was to be deduced by comparing the analogical teaching with conventional teaching methods. Conventional teaching methods were identified as those employing the usual minds-on approaches that teachers regularly employ in science lessons. These methods included use of explanations, discussions and question and answer techniques.

Objectives of the Study

The following specific objectives guided the study:

- To investigate if there is any difference in conceptualization of physical heat concepts between students taught using the dance analogy and those taught using conventional methods.
- To find out if there is any difference in students' misconceptions of physical heat concepts between those taught using the dance analogy and those taught using conventional methods.

Hypotheses

To achieve the objectives identified by the study, the following null hypotheses were formulated and tested at alpha level of 0.05.

Ho1: There is no statistically significant difference in conceptualization of physical heat concepts between students taught using the dance analogy and those taught using conventional teaching methods.

Ho2: There is no statistically significant difference in students' and misconceptions of physical heat concepts between those taught using the dance analogy and those taught using conventional methods.

Literature review

Learners' ideas on scientific concepts

There is already extensive literature based on studies around the world that indicates that students have ideas about natural phenomena well before formal instruction (Driver, 1989; Pfundt and Duit, 1994, Tsai, 1998). Sometimes these prior ideas, also referred to as preconceptions, are in harmony with accepted scientific theory (Hewsonand Hamlyn, 1984). However, in most cases, there are significant differences constituting misconceptions (Driver, 1995). Studies undertaken in physics education on students' conceptions of observable physical phenomena have documented a range of misconceptions held by the students. For example, Kaboro (2003) investigated and profiled secondary school students misconceptions of physical phenomena associated with heat in Nyandarua County, Kenya. This influenced location of the present study in the county. A summary of these misconceptions are summarized in Figure 1

Various sources of students' misconceptions have been identified. Solomon (1993) traces some of the misconceptions to beliefs that learners acquire from their societies' cultural knowledge. For example, Keraro (2002), found that students in parts of Western Kenya associated lightning with the appearance of a 'red cock', a common belief among communities in the region. Use of scientific terminology in the language of everyday life experiences has also been found to contribute to learners' misconceptions of scientific concepts. The terminologies reflect a mixture of both scientific and non-scientific meanings. For example Hewson and Hamlyn (1984) found that most of South African children used the word 'heat' in science classrooms in an incongruous mixture of scientific and everyday life experiences. Shumba (1995) observed that in most indigenous languages in Zimbabwe, 'half' was used to refer to any quantity that did not make a whole unit. Quantities more than and less than the 'scientific half' were referred to as a 'big half' and 'small half' respectively. Kaboro (2003) observed use of phrases that implied material characteristics of 'heat' commonly referred to as 'caloric conceptions' among students in Nyandarua County, Kenya. Such phrases included 'heat flows', 'heat moves' among others.

Inadequate explanations of observable physical phenomena by teachers and instructional materials also contributes to learners' misconceptions. In the absence adequate explanations, learners interpret new experiences by bringing their own existing mental schemes to bear on the experiences (Driver and Oldham, 1996). Review of the primary school science curriculum in Kenya revealed that pupils are introduced to macroscopic behaviour of matter when heated and cooled, for example, heat energy transfer thermal expansion and change of state in Standard V (grade 5) (KIE, 2012). However no explanations of the behavior are given, the assumption being that they are not cognitively ready to comprehend aspects of particulate nature and kinetic theory of matter. Driver and Easley (1998) articulated that "in learning about the physical world, alternative interpretations seem to be the product of learners' imaginative efforts to explain events and the abstract commonalities they see between them" (p.62).

An informal survey of textbooks approved by the Kenya Institute of Curriculum Development (KICD) for physics teaching in secondary schools revealed that very few have made a systematic attempt to help students understand aspects of particulate nature of matter. Some books have even directly misled students to attribute macroscopic properties of matter to individual particles of matter. For example, the idea of atoms and molecules is introduced by asking learners to "subdivide a piece of mater until they are unable to divide it any more" (KIE, 2005, p. 38). Clearly the final product of the subdivision process will have the same macroscopic properties as the original piece of matter. Based on studies on students' physical heat conceptions for example Kaboro (2003), Hewson and Hamlyn (1984), Tiberghien (1984) and Zietsman and Clement (1996), it is evident that students' ideas about 'heat' can be grouped into three viewpoints:

- **Caloric:** - Viewing 'heat' as having fluid material characteristics.
- **Pre-kinetic:** - Viewing 'heat' as a form of energy that manifests separately from particles of matter.
- **Kinetic:** - Viewing 'heat' as energy of particles of matter.

Erickson (1980) as cited in Kaboro (2003) observed that students' ideas about 'heat' improve from caloric, through pre-kinetic to kinetic conceptions. These conceptions were incorporated as choices in items in the heat concepts test HCT used in this study.

Facilitating conceptual change in science education

Students' ideas in science and the way the ideas change as a result of teaching can be identified as part of the broader picture concerning human learning (Driver, 1995). The issue of how conceptual change can be promoted is a matter of considerable interest and a subject of contemporary research.The results of this research suggest that there is a general trend in the way conceptions are constructed and modified (Calik, AyasandColl, 2009; DekkersandThijs, 1998; OrgillandBodner, 2004). The constructivist approach assumes that learners' prior conceptions are a necessary starting point of instruction. Teaching is then designed to enable the learner to develop prior conceptions to new conceptions.

In order to adopt the constructivist approach, a decision has to be made about the appropriate learning activities and experience to facilitate effective conceptual change. An important principle to consider in arriving at this decision is to start with the assumption that meaning is more effectively derived from episodes (Okere, 1996). This is because, according to cognitive psychology, it is the specifics of a situation that tend to be remembered more than the content or structure (Centingul and Geban, 2011). The implication of this is that science teachers need to give greater consideration to the experiences that learners will be exposed to in order to provide them opportunityto construct the desired conceptions. Using analogies during instruction is one way of facilitating learners'conceptual change in science education. Simply stated, an analogy is a process of identifying similarities between a familiar and an unfamiliar concept. The familiar concept is called the base or analog while the new concept to be learnt is called the target (Dilber and Duzgun, 2008). An analogy concretizes an abstract concept by comparing its aspects with those of a known phenomenon (Harrison and Coll, 2005). When learners see the link between the aspects, they are able to visualize the abstract concept.

Use of analogies has been found useful in concept learning in science, not only in conceptualizing abstract concepts but also in overcoming students' misconceptions. In physics education, Kigo (2006) used water flow analogy to help learners conceptualize electric current flow; Reiner (2000) used substance based concepts to teach a variety of concepts, for example, particulate nature of light; Clement and Brown (1989) used compressed springs to facilitate students conceptualization of force and its reaction; Tsai (1999) used dominoes to address students' misconceptions concerning aspects of particulate nature and kinetic theory of matter; Dilber and Duzgun (2008) used a train analogy to reduce students' misconceptions of electric current flow while Hong and Kok (2010) described solid, liquid and gas states by comparing the states to learners seated in their classroom, moving from one place to another in the laboratory and playing freely in the field respectively.

Review of literature did not identify any study in Kenya that attempts to use students' socio-cultural knowledge as the basis for selecting or developing a teaching analogy. In use of analogies there is also the need to consider the students' background so that the selected analogy is familiar to as many learners as possible (Glynn, 1991). This factor has largely been ignored. For example, in the water flow analogy used by Kigo (2006), how many of the students were familiar to the concept of piped water supply system given that most if the subjects were rural residents where water is mainly obtained from wells, dams and rivers? Review of literature did not identify any study in Kenya that attempts to use analogies to facilitate students' conceptualization of physical heat concepts. This study aimed at filling these knowledge gaps.

Dance Formation and Movement as a Means of Facilitating Conceptual Change

Throughout history, educational philosophers and educators have advocated movement as a way of promoting learning. Teaching and learning through creative movement provides learners with rich experiences that form a firm foundation of conceptual change (Skoning, 2008).Literature has documented benefits of using creative movement as a teaching tool. These include improved conceptualization (Werner, 2001); improved classroom behaviour with respect to interaction and inter-relationship among learners (Grant, 2005); development of creativity (Skoning, 2008) and enhanced interest to learn (Jackson, 2013).

Dance is a type of art that generally involves movement of the body often rhythmic to music and musical instruments (Yost, 2013). Dances are performed by many cultures as a form of emotional expression, social interaction and physical exercise (Griss, 1994). According to Yost, there are many styles and genres of dance which stem from the social, cultural, moral and aesthetical values of a society.In Africa, most traditional dances are characterized by functional movement with symbolic meaning (Kinyua, 2013). Jackson (2013) described science as about movement and therefore expressed that the concrete and functional movement in dance could be connected to abstract scientific ideas. However formal research into use of dance to teach core content in science remains sparse. This study employed the idea of using traditional dance formations and movement to teach aspects of particulate nature and kinetic theory of matter and its application in explaining observable physical phenomena associated with heat. For moral considerations, traditional dance was preferred to other contemporary dances. Nyandarua County is located within the central part of Kenya which is predominantly occupied by the kikuyu ethnic community. The kikuyu community is endowed with a rich cultural heritage in which music and dance are highly valued. 'Ndumo' and 'Mwomboko' are popular folk dances among the kikuyu community that have survived even after disappearance of other genres of neo-traditional dances (Kinyua, 2013).

'Ndumo' is usually performed by elderly women. It was traditionally performed to celebrate bamper harvest. It is characterized by a formation where the dancers dance in fixed positions to the ground. This movement was identified by this study as resembling vibration of particles of solid matter. 'Mwomboko' is traditionally performed by both men and women who dance in pairs. It is normally accompanied by sound from accordion and iron cymbals and its rhythm and tempo is determined by the intensity of the sound from the instruments (Gethoi, 2010). Kinyua (2013) has analysed the rhythmic, melodic and structural attributes of the dance in the context of kikuyu traditions. The dancers move as they count steps and then bend down rhythmically with heads bowing and hands held together and stretched sideways. The dancers move back and forth within the dancing arena as male dancers pause and grip the hands of the next female partners. This movement was identified as comparable to the behaviour of particles of liquids and gases in different temperature conditions. It was envisaged that if the intensity of sound from the instruments represented the intensity of heat energy and consequently the temperature, then the dancers and their movement would resemble that of particles of matter as explained in the kinetic theory of matter.

Theoretical Framework

The study was guided by conceptual change model which operates within a constructivist framework. Constructivists view learning as depending on the degree to which learners can construct new meanings from already existing mental schemes (Driver, 1995). The schemes are used by the learners to interpret new experiences by bringing them (schemes) to bear on the new situation in an attempt to understand it. Learning process then becomes an interaction between the learners' existing mental schemes and interaction between the learner's environment (Leach and Scott, 2003). What is learnt during instruction therefore depends on the prior ideas that the learners bring, the cognitive strategies they have available and their own particular interests and purposes.

Use of analogies in concept learning operates within the constructivist paradigm (Lakoge, Jegede and Oyebanji, 2007). The present study was undertaken with the assumption that the 'traditional dance' which is a familiar experience drawn from the learners' socio-cultural environment could successfully act as an anchor to facilitate conceptualization and reduce learners' misconceptions of physical phenomena associated with heat.

The constructivist model of learning when adapted in this study was conceptualized as in Figure 2.

MATERIALS AND METHODS

Research design

Quasi–experimental research involving the Solomon Four Non-equivalent Control Group Design was used. Secondary schools in Kenya are taught as intact groups and authorities do not normally allow classes to be dismantled for research purposes. Therefore randomization of individual students into the design groups was not possible. The design used has advantages over other experimental designs because according to Fraenkel and Wallen (2000), it controls the major threats to internal validity. The conditions under which the instruments were administered were kept as similar as possible across the schools in order to control instrumentation and selection. The schools were randomly assigned into the design groups to control for maturation and interaction (Borg and Gall, 2007).

The set-up of the study exposed the experimental groups E_1 and E_2 to teaching physical heat concepts using the traditional dance analogy while the control groups C_1 and C_2 were taught using conventional instructional methods. According to Cohen and Manion (2012) an experimental comparison is designed such that the control group is subjected to the usual set of conditions while the experimental group is subjected to the unusual or novel treatments. The summary of the design is illustrated in Figure 3.

In Figure 3, e_1 represent the experimental groups, c_1 the control groups, X the experimental treatment while O_i represent observations on pretest and posttest.In the experimental treatment, the Teaching-With-Analogy (TWA) model advanced by Glynn (1989) was adopted with modifications. In his model, Glynn proposed six steps namely introduction of target concept, recall of analogy concept, identifying similar features of the target and analogy concepts, mapping the similarities drawing conclusions about the concepts and analyzing the cases where the analogy breaks down. In this study the third and fourth steps were merged to simplify the process and eliminate what was considered as overlap of operations.

Phenomenon	Misconceptions
Nature of 'heat'	'Heat' taken as an absolute end state, for example, 'heat is the state an object becomes when its temperature rises.
Interaction of heat energy with matter	'Heat' has weight and occupies space. When an object is heated, the heat energy is absorbed and stored in the molecules. Heating initiates vibrations of molecules of object
Heat energy transfer	'Heat' has material characteristics, for example 'heat moves from Point A to point B.
Change of state	'Heat' occupies space within the material causing the material to expand and eventually change state. Heating makes molecules of object to change state
Thermal expansion	'Heat' occupies space within heated object causing the object to expand. Molecules of the heated object expand. Molecules multiply/increase in number, increasing the size of the heated object.

Source: Kaboro (2003)

Figure 1. Students' misconceptions of physical phenomena associated with heat in secondary schools in Nyandarua County, Kenya

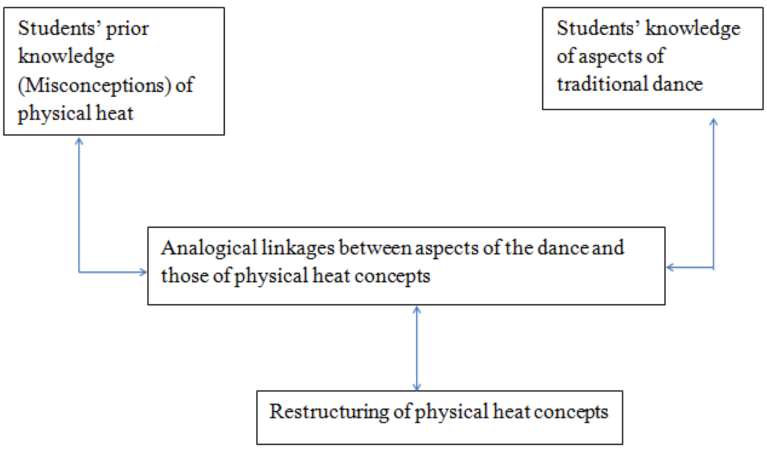

Figure 2. Process of conceptual change of physical heat concepts facilitated through dance analogy

Group	Pretest	Treatment	Posttest
E_1	O_1	X	O_2
C_1	O_3		O_4
E_2		X	O_5
C_2			O_6

Source: Cohen and Manion (2012,p.398)

Figure 3. The Solomon Four Non-equivalent Control Group Design

Therefore the process involved introduction of Heat Concepts, performance of the Traditional Dance, identifying and mapping similar features between the dance and heat concepts, drawing conclusions and identifying cases where the analogy broke down. The similarities between aspects of the dance phenomenon and physical heat concepts that were emphasized are illustrated in Figure 5.

The first step was to identify all schools in the county that possessed these characteristics. To minimize contamination among the design groups it was found appropriate to have the four schools (each in the respective design group) located in different sub-counties within the county. The first phase of sampling involved random selection of four among the seven sub-counties in Nyandarua County.

Traditional dance concept	Physical Heat concept
a)Individual dancers	a)Atoms of matter
b)Pairs of dancers	b)Molecules of matter
c)Music from instruments	c)Heating
d)Dancing rings	d)Space/volume occupied by matter
e)Dancing troupe	e)Matter
f)Increased sound from instruments	f)Increased heating
g)Decreased sound from instruments	g)Decreased heating /cooling
h)Intensity of dancing	h)Rate of random motion/vibration of molecules/atoms.
	i)Thermal expansion of matter
i)Expansion of dancing space	j)Random collision of gas particles
j)Exchange of dancing partners	k)Change of state
k)Occupation of different balancing rings	

Figure 4. Link between aspects of Traditional Dance Concepts and those of Physical Heat Concepts

Q. Which one of the following statements correctly describes molecules of heated water?

A. Molecules of water increase in size but occupy their respective positions.
B. Molecules of water retain their original size but move farther apart.
C. Molecules of water mix with heat molecules

- Different answer……………………………………………………………
- Reason for your answer………………………………………………
- How confident are you that the answer you have indicated is the correct answer?

☐ Very confident ☐ Confident ☐ Fairly confident ☐ Not Confident

(Tick appropriately)

Figure 5. Sample item in the Heat Concepts Test (HCT)

Emphasis was laid on the cases where the analogy broke down, namely comparability between number of particles of matter and those of the dancers, space between particles of matter which is empty compared to the space between pairs of dancers which has air, size of particles of matter which is negligible when compared to the space occupied by matter as opposed to dancers who occupy appreciable space with respect to the dancing space and the rate of motion of particles of matter which is very high compared to movement of dancers.

Target population and sampling procedures

The target population comprised all Form I (grade 9) students in secondary school in Nyandarua County, Kenya.According to the secondary school physics syllabus, students are introduced to aspects of kinetic theory of matter at this level.Gender balance was achieved by conducting the study in mixed secondary schools.In research it is not necessary to capture data from all subjects in the target population in order to understand the phenomenon being studied. Observations can be made on a small portion of the population and the findings generalized to the population as long as the sample is representative of the population (Mbeche, 2004). It was necessary to ensure that the Form I classes selected had at least 30 students per class and approximately equal number of boys as girls. In addition, it was important that the selected schools had a physics laboratory and that the classes were being taught physics by graduate teachers with at least three years teaching experience.

Simple random sampling was then used to select one school in each of these sub counties. The four schools were randomly assigned into the four groups in the research design. This process generated the results in Table 1.

Instrumentation

A Heat concept Test (HCT) was used to assess students' conceptualization of physical heat concepts. The test consisted of 12 multiple choice items. Each item comprised two parts. The first part asked respondents to give an answer to the multiple choice question. Three alternatives were provided, each representing the three view points on heat conceptions namely caloric, pre-kinetic and kinetic. A blank space was also provided for the respondent to write her/his own answer, if in her/his opinion the choices provided did not comprise a correct answer. In this case, the respondent was required to give a reason to support the answer. This provided the researchers an opportunity to assess and categorize the answers as either caloric, pre-kinetic or kinetic. Students responses were assigned scores; 1 for caloric; 2 for pre-kinetic and 4 for kinetic conceptions. The total score on the test was used as an indicator of the students' conceptualization of physical heat concepts. The second part of the item required the respondents to indicate their level of confidence in the answer given in the first part. The aim was to identify students' misconceptions. A wrong response in the first part which was marked 'very confident' or 'confident' in the second part was considered a misconception.

Table 1. Sub counties selected and sample size in identified schools

Design group	Sub-county	Number of students (n)
E_1	Nyandarua central	44
C_1	Nyandarua North	48
E_2	Nyandarua West	46
C_2	Kipipiri	37
Total (N)		175

Therefore the total number of misconceptions for a student ranged from 0 to 12. The concepts covered in the HCT included temperature, direction of heat energy transfer, expansion caused by heating, change of state effect of heating on space between molecules, effect of heating on mass/weight of matter, effect of temperature on random motion of gas molecules and effect of temperature on size of molecules of mater. In constructing the items of the HCT, specific syllabus objectives related to physical heat concepts, as well as literature on students' misconceptions of physical phenomena associated with heat as profiled by Kaboro (2003), were considered. The post-HCT comprised of similar items as those of pre-HCT except for the specific situations in which the concepts were applied. The following is a sample item in the HCT. The instrument was given to four experts in science education for validation.

The tests (pretest and posttest) were pilot tested in two schools that had similar characteristics as those the sample schools. The pilot schools were selected in sub counties besides those selected for the main study within Nyandarua County. The results of the pilot study were used to assess the reliability of the instrument using Cronbach's coefficient alpha. This technique is suitable when the items measure a single construct (Peil, 1995). The reliability coefficient wascalculated as 0.79 which was well above the recommended threshold of 0.70 for an instrument to be considered suitable in making accurate inferences in social sciences (Fraenkel and Wallen, 2000)

Administration of treatment and data collection procedure

The content of physical heat concepts used during class instruction was developed based on the revised KIE (2002) physics syllabus. Teachers in the experimental schools E_1 and E_2 were trained on the use of the dance activity to explain particulate nature and kinetic theory of matter as well as explanation of physical phenomena associated with heating and cooling of matter. Pretest was administered to groups E_1 and C_1. This was followed by teaching of physical heat conceptsin four period I lessons. In the experimental groups E_1 and E_2, links were drawn between aspects of the traditional dance and those of the behaviour of particles of heated or cooled matter. The teachers also explained cases where the analogy broke down. At the end of the teaching period, post HCT was administered to all groups.Marking of students' responses was done by the researcher and the means for the groups with respect to conceptualization and number of misconceptions of physical heat concepts computed. The results were subjected to statistical analysis in order to test the hypotheses of the study.

Data analysis

Analysis involved comparing the means of the groups with respect to conceptualization and the number of misconceptions of physical heat concepts.

To compare the means of the groups E_1 and C_1 on pretest, students' t-test was used. This statistic is suitable for comparing the means of two groups (Cohen andManion, 2012). To test the significance of the difference among means for all the groups on posttest scores, analysis of variance (ANOVA) was used. According to Borg and Gall (2007), this statistic is suitable in comparing the means of more than two groups because it can be applied once. Tukey-Kramer post hoc tests were run to establish the significance of the difference between all possible pairs of sample means. This test is superior to other post hoc tests in terms of maintaining the alpha level in the tests of significance and is suitable in cases where the means are unequal (Hall, 1998). The null hypotheses were tested at an alpha level of 0.05.

RESULTS

The study sought to determine the effect of using the traditional dance analogy on conceptualization of physical heat concepts. This was achieved by comparing achievement of students on the HCT between those taught using the analogy and those taught using conventional teaching methods. The Solomon Four Group Designs enabled the researcher to compare the characteristics of the true experimental and control groups E_1 and C_1 respectively before administration of instruments with respect to their conceptualization and misconceptions of physical heat concepts. The results of the mean scores for groups E_1 and C_1 on pre- HCT and the t-test analysis of the significance of the difference between means are displayed in Table 2.

Table 2. T-test analysis of the Significance of the Difference between Means for Groups E_1 and C_1 on Pre-HCT

Groups	N	Mean	SD	df	t-value	P-value
E_1	38	22.61	3.07	78	0.875	0.384
C_1	42	23.24	3.37			

An inspection of Table 2 shows that the mean of the control group C_1 (Mean = 23.24 SD = 3.37) was slightly higher than that of the experimental group E_1 (Mean = 22.61, SD = 3.07). However, t-test analysis revealed that the difference was not statistically significant at $\alpha = 0.05$, ($t(78) = 0.875$, $P > 0.05$). Hence the groups were comparable with respect to conceptualization of physical heat concepts.Analysis of students' misconceptions on physical heat concepts using pre-HCT showed that students in group E_1 had slightly more misconceptions (Mean = 9.97, SD = 1.57) compared to students in group C_1 (Mean =9,81, SD = 1.42). The difference was subjected to t-test analysis for statistical significance. The results are displayed in Table 3.

Table 3. t-test Analysis of the Significance of the Difference between the Mean Number ofStudents' Misconceptions of Physical Heat Concepts using Pre-HCT

Group	Mean	SD	df	t-Value	P-Value
E_1	9.97	1.57	78	0.492	0.624
C_1	9.81	1.42			

Results indicated that the observed difference was not statistically significant ($t(78) = 0.492$, $P> 0.05$). It was therefore concluded that students in the two groups were similar with respect to misconceptions on physical heat concepts. Hypothesis Ho1 of the study sought to find out whether there was any statistically significant difference in conceptualization of physical heat concepts between students taught using the dance analogy and those taught using the conventional methods. Analysis of students' scores on post-HCT for the groups produced the results shown in Table 4.

Table 4. Students' Mean Scores on post-HCT for Groups E_1, C_1, E_2 and C_2

Group	N	Mean	SD
E_1	38	44.32	2.61
C_1	42	31.93	4.83
E_2	44	43.32	3.87
C_2	35	32.26	2.96

Table 4 shows that the groups scored differently on post-HCT. ANOVA test of significance for the difference among the group means yielded the results in Table 5. The results show that the mean differences among groups were statistically significant at $\alpha = 0.05$. To identify the pairs of groups with statistically significant differences between means, Tukey–Kramer post hoc tests were carried out. The results are displayed in Table 6.

Table 5. ANOVA Test of Significance of Difference among Group Means on Students' Scores on Post – HCT

Source of Variance	Sum of squares	df	Mean square	f- value	p- value
Between groups	5460.74	3	1820.25	131.27	0.00*
Within groups	2149.23	155	13.87		
Total	7609.97	158			

$(F(3,155) = 131.27, P<0.05)$

Table 6. Tukey-Kramer's post Hoc Comparisons of Students' Mean Scores on Post – HCT for Groups E_1, C_1, E_2 and C_2

I Group	J Group	Mean Difference (I-J)	P-value
E_1	C_1	12.39*	0.00
	E_2	1.00	0.621
	C_2	12.06*	0.00
C_1	E_1	-12.39*	0.00
	E_2	-11.39*	0.00
	C_2	-0.33	0.98
E_2	E_1	-1.00	0.62
	C_1	11.39*	0.00
	C_2	11.06*	0.00
C_2	E_1	-12.06*	0.00
	C_1	0.33	0.98
	E_2	-11.06*	0.00

*represent statistically significant difference

Results in Table 6 indicate statistically significant differences between the means of E_1 and C_1, C_1 and E_2, E_1 and C_2 and E_2 and C_2 at $E_1\alpha = 0.05$ level with the means of the experimental groups higher than those of the control groups. However the mean differences between groups E_1 and E_2 and C_1 and C_2 were not statistically significant.

Mean Number of Students' Misconceptions of Physical Heat Concepts for GroupsE_1, C_1, E_2 and C_2

Group	Mean	SD
E_1	1.34	1.05
C_1	6.48	2.33
E_2	1.07	1.23
C_2	5.77	1.63

These results indicate that teaching using the dance analogy led to significantly higher gains in conceptualization of physical heat concepts compared to teaching using conventional methods. Consequently hypotheses Ho1 was rejected. The mean differences between groups E_1 and C1 on one hand and between groups E_2 and C_2 on the other were 12.39 and 11.06 respectively. The differences are comparable, implying that the analogous teaching method had almost similar effect on both the pretested and un-pretested groups. Hypotheses Ho2 postulated that there would be statistically significant difference between the number of students'misconceptions of physical heat concepts for those taught using the dance analogy and those taught using conventional methods. Analysis of students' misconceptions using post-HCT yielded the descriptive statistics in Table 7.

Results indicated lower means for the experimental groups E_1 and E_2 compared to the control groups C_1 and C_2.One way ANOVA was used to test the differences among group means for statistical significance. The results of the test are displayed in Table 8. Examination of the results in Table 8 revealed that the differences among the group means were statistically significant $(F (3, 155) = 122.15, p<0.05)$ at $\alpha = 0.05$. Tukey-Kramer post hoc tests of multiple comparisons revealed the pairs of group means that were statistically significant. The results are displayed in Table 9.

Based on the results of the analysis in Table 9, it is evident that the means of experimental groups were significantly lower than those of the control groups. Therefore students taught using the dance analogy had significantly lower misconceptions of physical heat concepts at the end of instruction compared to those taught using conventional methods. Consequently hypothesis Ho2 was rejected.

DISCUSSION

Results indicated that teaching using the dance analogy resulted in better conceptualization and produced greater impact in reducing students' misconceptions of physical heat concepts.

Table 8. ANOVA Test of significance of the Difference among Group means on students' misconceptions of physical heat concepts

Source of variance	Sum of squares	df	Mean square	F-value	P-value
Between groups	988.243	3	329.414	122.153	0.000*
Within group	417.996	155	2.697		
Total	1406.239	158			

*(F(3, 155) = 122.15, p<0.05)

Table 9. Tukey-Kramer Post-Hoc Comparisons of Students' Misconceptions of Physical Heat Concepts for GroupsE_1, C_1, E_2 and C_2

I Group	J Group	Mean Difference (I-J)	P-value
E_1	C_1	-5.13*	0.00
	E_2	0.27	0.875
	C_2	-4.43*	0.00
C_1	E_1	5.13*	0.00
	E_2	5.41*	0.00
	C_2	0.70	0.243
E_2	E_1	-0.27	0875
	C_1	-5.41*	0.00
	C_2	-4.70*	0.00
C_2	E_1	4.43*	0.00
	C_1	-0.70	0.243
	E_2	4.43*	0.00

*represent statistically significant difference

Use of analogies in concept learning works under the broad category of advance organizers. According to Shihusaand Keraro (2009), an advance organizer is any attempt to prepare the mind of the learner to conceptualize a new concept. Advance organizers help the learner to associate new learning with familiar phenomenon (Glynn, 1991). The nature and the strength of the established associations determine the magnitude of conceptual change and retention of the learnt knowledge (Okere, 1996).

The findings are consistent with those of other studies that established effectiveness of teaching various concepts in science using analogies (Dilber and Duzgun, 2008; Hong and Kok, 2010; Kigo, 2006; Tsai 1998; Tsai 1999). The studies found analogous teaching not only effective in facilitating conceptualization but also in addressing students' misconceptions of scientific concepts. However, most of the analogies were based on physical processes that did not consider the important factor of learners' socio cultural knowledge as used in this study.Explanation of the bulk properties of matter in terms of kinetic theory of matter is abstract (Nelkonand Parker, 2000). Teaching of these concepts is less likely to be achieved effectively using conventional means (Tasker and Dalton, 2006). The dance analogy enabled learners to relate the behaviour of particles of matter to the dancers under different temperature conditions. It was envisaged that the analogy could address students' misconceptions of physical heat concepts. For example students could infer that the separation of the particles and not the size of the particles would change as a result of expansion and phase change, because in the dance it is the separation and not the size of the dancers that changed. Also learners developed the idea that movement of particles would be faster at higher temperatures just as the dancers danced more vigorously with increased intensity of music from instruments.Learners observed that no material transferred from the musical instruments to the dancers. This resonated with the ideathat in heating or cooling no material transfers from the source of heating or the matter being heated thereby addressing students' caloric misconceptions about heat transfer.

Conclusions

Based on the findings of this study and with respect to the hypotheses posited for testing it can be concluded that facilitating conceptual change with regard to physical heat concepts is more effectively achieved using analogous teaching compared to using conventional teaching methods. This implies that learners' socio-cultural knowledge can be meaningfully exploited to derive analogies to teach abstract science concepts. From the results of the study, two instructional implications can be drawn. Firstly, to overcome students' misconceptions in science, analogous teaching can be used as an effective tool. However it should be noted that despite teaching using the analogy, a number of misconceptions still persisted. Chin and Brewer (1983) explained that it is very difficult to eliminate completely students' misconceptions. Secondly, the study provides evidence that the dance analogy facilitated better conceptualization compared to conventional teaching methods. Science teachers should therefore be encouraged to identify suitable analogies and use them to facilitate conceptual change in teaching abstract concepts.

Recommendations

As demonstrated in this study experiences grounded in learners' socio-cultural environment can be usefully integrated in learning scientific concepts within a constructivist's model. Curriculum developers in physics and in science in general should consider incorporating instructional activities that are grounded in learners' social contexts to facilitate effective conceptual change in concept learning. Students in primary and secondary schools in Kenya show great interest and enthusiasm towards the annual Kenya schools music and drama festival.

Teachers could usefully exploit this scenario to integrate scientific themes within the music and dances thereby not only facilitating conceptualization, but also enhancing interest and motivation to learn science concepts. Universities and institutions that train secondary school science teachers in general and physics teachers in particular should find the results of the study useful in developing programmes aimed at building the capacity of the teachers to design and use instructional approaches that incorporate analogies. As demonstrated in this study when analogy is used in a systematic manner, it can serve to facilitate effective learning of abstract concepts as well as address learners' misconceptions. The features of the dance analogy used in this study can be easily implemented within the classroom set up. This aspect can be used to construct a reasonable introductory level treatment of particulate nature and kinetic theory of matter in the science curriculum of primary schools in Kenya. This could form a basis for explaining observable physical phenomena associated with heating and cooling of matter to pupils in primary schools, hence shielding them from developing misconceptions in the absence of adequate explanations.

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