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THE USE OF THE TREAGUST STRATEGY TO PROMOTE ENTHUSIASM FOR LEARNING SCIENCE SUBJECTS AND THE GROWTH OF SCIENTIFIC IDEAS IN PRIMARY SCHOOL STUDENTS

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ABSTRACT

This study examines the effect of the Treagust strategy on the development of an understanding of science concepts in Saudi primary school students and on developing an understanding of science concepts in Saudi primary school students and promoting their motivation to learn science. A quasi-experimental design (i.e., one experimental group) was adopted, and pre- and post-learning measurements were administered. The sample consisted of 13 fifth-grade students. The instruments tools of the study were the Science Achievement Test and the Motivation towards Learning Science Scale. The overall results indicated that the programme was effective in improving effectively improved science achievement, as there was a significant difference between the mean scores of the pre- and post-learning measurements at the 0.01 level in the MCQ test, favoring the post-learning measurement. Furthermore, statistically significant differences were found between the pre- and post-learning measurements in the dimensions of self-esteem, performance, and achievement; the only insignificant subscale was the value of learning science. The research concludes with a presentation and discussion of recommendations and future research topics in light of the findings.

Keywords: analogy; primary school students; scientific ideas; science learning motivation; treagust strategy

INTRODUCTION

According to Kılıç and Topsakal (2011), numerous complex scientific concepts exist. Through the study of science, an avenue is made available for examining the fundamental laws of nature, several abstract and complex scientific processes and techniques, and multiple daily science concepts (Maharaj-Sharma & Sharma, 2017). Typically, students use science textbooks for understanding concepts in their primary school years. It should, however, be noted that students find it difficult to use textbooks for learning. As Al Ghamdi and Al-Salouli (2013) noted, the new curricula in Saudi Arabia significantly highlights student-centred learning and comprehending concepts rather than memorizing, thus creating meaningful links to the lives and experiences of students.

Further, the constructivist learning theory is used as a teaching approach in the new curricula. Moreover, as stated by Çetingül and Geban (2011), according to constructivist learning theory, learning does not come from teaching but from how students process the new information given to them. It has been noted that students tend to reject any new information that is not per their prior knowledge, thus not learning anything when they leave the classroom. As stated by Maharaj-Sharma and Sharma (2017), analogies are used extensively as tools to teach complex science concepts. It has also been recommended in the li-

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terature that analogies may work as efficient tools for aiding learners in comprehending abstract and/or complex concepts presented in classroom learning, particularly considering the conceptual change in the constructivist paradigm is regarded as a vital part of learning (Maharaj-Sharma & Sharma, 2015).

Moreover, Çetingül and Geban (2011) stated that several experimental studies have investigated how analogies impact the learning of complicated scientific content and enhance conceptual change. They also noted that analogies help students better understand new information as it compares it to that which they already know. Suryani et al. (2021) argued that "students' attitudes are determined by the knowledge they have" as noted by Rahayu and Sutrisno (2019), several students not only pay attention to but also enjoy and remember analogies provided by their instructors. It should be noted that Saudi students take an interest in scientific topics when it is relevant to their everyday lives and experiences.

Romero et al. (2020) argued that "students' increasing lack of interest in science has led to a disturbing situation that compels us to continue researching educational motivation." Trumper (2006) also stated that learning and teaching science are both essential components of science education and must be thoroughly investigated. Many researchers have evaluated the importance of positive attitudes towards scientists and science. Therefore, it is necessary to implement various strategies, resources, and teaching styles to ensure that students enjoy science education and find it accessible (Kallery, 2011). Such an analogy aids students in comprehending, visualising, and remembering their classroom learning (Rahayu & Sutrisno, 2019). Çetingül and Geban (2011) also stated that although attention and motivation are crucial in learning, a more important factor is what the students have already learnt. Understanding the pre-instructional concepts that result in the students' current thinking can help students develop ways to question these beliefs and surpass them. Further, according to Kılıç and Topsakal (2011), sixth-grade students may not be able to process abstract ideas, so they may find it difficult to form analogies. Thus, implementing the method of analogues in the new studies concerning students in the more advanced stages may be more helpful. Hence, this study states that it is essential to conduct more research on implementing the analogy technique in the lower stage to examine its impact on developing science-based ideas and the fifth-grade students' motivation for learning science. This is crucial as it can add to the limited literature on implementing analogies concerning science teaching and learning in Saudi Arabia. The present study's examples, suggestions, explanations, and considerations may provide science teachers, particularly those in Saudi, with a better understanding, more resources, and encouragement regarding using analogies when teaching.

Abdul Gafoor and Shilna (2013) indicated that three such teaching guides had been put forward within the literature on the use of analogies: the FAR (Focus, Action, Reflection) model (Treagust, 1993), which is known to be the least difficult of the three; the TWA (Teaching With Analogies) model (Zeitoun, 1984); and the GMAT (General Model of Analogy Teaching) model (Glynn, 1991). Notably, all analogies possess unshared qualities, so all tend to lose effectiveness after a certain period (Harrison & Treagust, 2006). Further, these same researchers cite Glynn (1991) and Duit (1991) while detailing the specifics of this issue further, evaluating Glynn's (1991) Teaching-With-Analogies (TWA) model and stating that teachers frequently neglected a couple of stages of the strategy, usually as a result of diversions and interruptions within the classroom atmosphere (Harrison & Treagust, 2006).

Abdul Gafoor and Shilna (2013) indicate that the producer of the FAR model considered the other two models to be overly complicated, considering the number of steps they comprise; thus, Treagust (1993) aimed to produce a guide that could be recalled easily by teachers. It was additionally pointed out by Harrison and Treagust (2006) that the diversity/rate of substitute ideas significantly decreased, and the overall grasp of the topic at hand increased after the implementation of analogies in line with the FAR guide framework.

The FAR model comprises three phases or steps for teaching with analogies: the focus phase, in which the teacher ascertains the idea; the action phase, in which the teacher and pupils deliberate the analogy, along with any variations between the source and target item; and the reflection phase, during which the results of using this analogy are deliberated, and the use of the analogy is enhanced accordingly (Gafoor & Shilna, 2013).

Harrison (2006) found that interest and incentive are essential to successfully comprehend the concepts at hand. Indeed, if the pupils have no personal interest in the topic, the lengths to which they will understand any teaching are dramatically decreased. It has been proven that analogy use within teaching is connected to students' accomplishments. As is commonly known, students' accomplishment is pivotal during learning, as it leads both the student and the teacher to track the student's progress (Al-Mosawi et al., 2015). Analogies can be used to construct new learning material that sparks students' interest, especially when an analogy is connected to students' prior knowledge (Thiele &Treagustm 1994). According to McComas (2013), analogies can enable pupils to reorganise their knowledge frameworks in a way that is easier to comprehend. Duit and Glynn (1996) highlighted that pupils only openly accept the use of analogies when the topic at hand is complex.

From the above, we can see that the evaluation of analogy relevance and effectiveness should be frequent and concluded upon reflecting on the pupils' specific experiences, pre-existing concepts, and requirements. Indeed, the most successful analogies are uniquely tailored to the pupils at hand. The only sources/Analog used are those familiar to the learners to prevent misunderstanding and enhance grasp of the topic.

Furthermore, analogies can enhance student communication and engagement with the topic. In addition, a link has been found between student enthusiasm concerning the science curriculum and student accomplishments within the classroom (Jarvis & Pell, 2005). This connection works as a cycle: an increase in students' enthusiasm leads to an increase in the number of their accomplishments (Sharman & Khatabiya, 2012; Salih, 2017). Since it inspires them to seek improvement, students' enthusiasm for a scientific subject is strongly related to their educational accomplishments; this is particularly true when a teacher utilises current teaching strategies rather than traditional methods (Salih, 2017). As cited by Dilber and Duzgun (2008), analogies aid pupils' understanding of a topic via the conceptualisation of an idea, achieved via pinpointing any similarities and differences between the newly introduced concept and the students' pre-existing schemas. Furthermore, because learners can build such associations between their personal life and the new concept, personal interest and motivation in the topic can be increased.

Notably, students vary in terms of their attention span and reaction to motivational strategies in science; students will be attracted to a science-related subject when it fulfils their needs. Enthusiasm for learning is an internal sensation that triggers positive behaviour, which continues until any objectives have been attained (Sharman & Khatabiya, 2012). It is well known that students' drive within the classroom stems from faith in their skills to fully comprehend and solve a problem and their interest in the subject. Analogies can positively affect both influences and thus promote students' drive.

A study by Kılıç and Topsakal (2011) evaluated the impact of student-centred and teacher-centred analogies on the students' academic achievements, conceptual understanding, and attitude regarding the circulatory system in terms of a science and technology lesson. For this study, a quasi-experimental design was implemented with 49 sixth-grade students in Turkey as the sample size. The findings showed a considerable difference in the pre-test and post-test results of both groups of students concerning their academic achievements, conceptual understanding, and attitude regarding the science course.

Students who have difficulty understanding a concept will provide their interpretation as a process of reconstructing initial and new knowledge (Haidar et al., 2020). The effect of teaching using analogies on removing students' misconceptions about physics and direct current circuits, as well as on students' accomplishments, was explored by Ugur et al. (2012). Their study involved 51 eleventh-grade students from two separate classrooms; the control group was taught using traditional methods, while the experimental group was taught lessons with analogies incorporated. The results demonstrated that using analogies had a strong positive effect on removing misconceptions; however, they also demonstrated that the analogies had virtually no influence on the students' attitudes towards physics lessons.

In the same vein, Genc conducted a study in 2013 to explore the impact of teaching with analogies on pupils' academic progress and their attitudes concerning adopting analogies. The conclusions derived from this study indicated that teaching with analogies was more effective regarding learners' attitudes and academic progress than traditional teaching. Since the analogies aided them in grasping a complex idea, most of the learners in this study dubbed the analogies as very useful and conducive to long-term learning, further claiming that they would usually find such concepts difficult to comprehend with traditional teaching methods.

In a similar study, Devecioglu-Kaymakci (2016) explored how the 5E Learning Model impacts learning (specifically of the topic of the solar system) during analogical model adoption, additionally utilising the pre-experimental design as a form of data collection post- reflective thinking scale, questionnaire, informal observations, and video recording; this study comprised of 20 seventh-grade students in the Black Sea Region, Turkey, an expertly developed analogical model being applied to the subjects in a lesson governed by the 5E Learning Model for a total of two hours. This study concluded that, to achieve optimal effectiveness, analogies should be well thought-through and primarily utilised for teaching science subjects as, indeed, the results of this study were highly positive, both academic progress and attitudes of the students rapidly increasing with the use of the teaching intervention.

The occasional discrepancies between study findings concerned with whether learning index implementation is beneficial compared to traditional teaching methods are explained. According to Vosniadou and Skopeliti (2019), there are inconsistencies in how much prior knowledge the subjects have when participating in this study and in terms of which learning index is investigated. These two indexes were then adopted in two investigations—comprised of students in third and fifth grades in the former study and students in sixth grade and college in the latter—wherein a science lesson was conducted—once with analogies, once without—, the results and differences between the two forms of teaching then being compared. The results concluded that very few students successfully learned the topic. It was still apparent that those exposed to analogies within their text garnered better results in their pre-test, post-test, and delayed-test summaries, reciting more accurate information about the topic.

The science curriculum in Saudi Arabia is considered to be an area for enhancement and growth in students' thinking skills; this focus emphasises the importance of using current and reliable teaching techniques for student involvement in discussions, research, dialogue, and logical thinking (Sudah & Ibrahim, 2017). On a similar note, according to Alshaya and Abdulhameed (2011), even though currently used Saudi textbooks for science subjects advocate the growth of scientific literacy, learning on the grounds of inquiry, and formative assessment strategies, the typical teaching method within this country, on the contrary, prioritises the curriculum, good memory within exams, and neglectful teaching techniques in terms of students' pre-existing knowledge and how their minds differ when it comes to what teaching methods work most effectively for them; indeed, if given a chance to express such pre-existing knowledge, students would have the freedom to be able to put across their scientific thoughts and concepts during lesson-time (Driver et al., 1985; Osborne & Freyburg, 1985). Notably, students frequently come up with their thoughts and feelings regarding scientific subjects, lending the way to the growth of misapprehensions about the topic (i.e., as defined by Aldahmash and Alshaya (2012)), illogical or incorrect ideas concerning a particular topic/process made by learners, frequently as a result of their misconceptions within other topics and/or from past encounters. Professors give such misconceptions no attention, thus, leading to inefficient learning and minimal academic achievements in science topics (Mortimer, 1995; Al-Mosawi et al., 2015).

As noted by Otero et al. (2010), science as an overall practice offers the possibility for us to comprehend a range of difficult and abstract procedures, i.e., as defined by Genc (2013), things that cannot be experienced by any of the five senses and tactics, as well as the general fundamental laws of nature. As mentioned above, abstract concepts are generally not easy to understand, thus leading to the necessity behind the formation of a technique that simultaneously adapts such complex content for easy learning for students and allows teachers to teach with ease (Al-Mosawi et al., 2015). For a learning process within any given topic to be successful, content has to be taught in a way that is specifically meaningful for the student (Ausubel, 1968), thus permitting pupils to implement the knowledge learnt in the classroom in real life in future years (Aldahmash & Alshaya, 2012).

Despite all of the above research pinpointing analogies as being highly effective, recent studies also observe that Saudi teachers are still turning to memorisation-focused teaching methods. Hudha et al. (2021) argued that although science teachers use textbooks as "resources to support the planning and implementation of science lessons," textbooks have not satisfied an important role in science education, particularly in primary schools. The traditional learning practice that "the students as a passive participant in receiving all the information or knowledge" (Hadibarata &. Rubiyatno, 2019). However, a strategy similar to the Treagust Model would be more suitable. This model encourages pupils to form connections between the current topic and previous personal experiences, the learner thus being the focus point of the entire learning process, the teacher simply providing pointers as and when needed (Devecioglu-Kaymakci, 2016).

During their educational journey, students are taught numerous simplified topics that prioritise telling the facts provided by the science curriculum over giving the students a meaningful learning experience (which is attained when the student remembers the facts they are told and can understand what they were told). The key issue in teaching science is that students struggle to comprehend scientific concepts; thus, they feel less enthusiastic about studying science. For this reason, the researcher was motivated to use the FAR model, a model of the analogies strategy created by Treagust (1993). The present study aims to determine how teaching and learning scientific concepts could be enhanced with this model and identify the degree to which it could positively impact students' motivation level and tackle the issues they face. The research questions are as follows: (1) How effective is the Treagust model in developing the science-based ideas of fifth-grade students?; (2) How effective is the Treagust model in developing the motivation of fifth-grade students to learn science?

METHODS

The researcher adopted a quasi-experimental study design involving a single experimental group investigating the effectiveness of the independent variable (teaching with the analogies strategy, particularly the Treagust model) on the dependent variables (learning science and motivation) among fifth-grade students in the Al-Jouf area. The sample comprised 13 fifth-grade students, and the study was conducted during the second semester of 2018. The school in question was randomly selected, and the participants were recruited using random sampling. In Saudi Arabia, all fifth-grade students have studied science for four years. Al-Jouf was chosen because the researcher lives and works there, making conducting the research easier.

The present study adopted the Treagust model (1993), which suggests that teachers follow three steps when teaching science using the analogies strategy. As mentioned earlier, Treagust summarises these three steps using the acronym FAR (Focus, Action, and Reflection). The programme was based on the fifth-grade science syllabus for the second semester of the year and included lessons from Chapter 10, titled "Physical and Chemical Changes of Matter." (Figure 1 and 2).

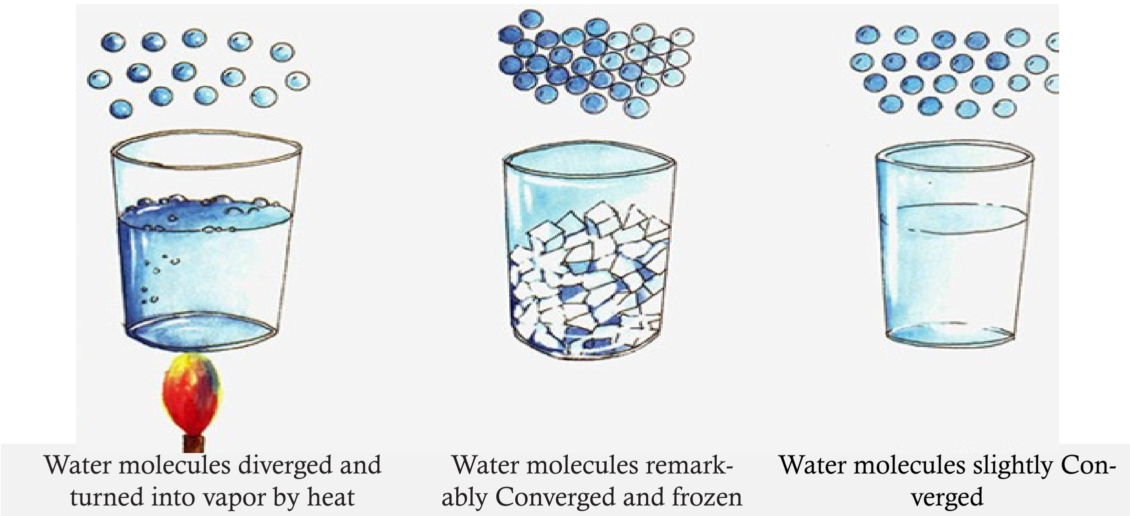

Figure 1. Physical Change: A Change in the Size, Shape, and/or Colour of Matter

To achieve the study objectives and answer the first research question, a teacher's guide was created to enable the teacher to use the analogies strategy based on the Treagust model when teaching the unit titled "Thermal Expansion of Metals." This task included developing a thorough understanding of the analogies concept and its rules and principles, determining how to use the Treagust model effectively, and establishing the steps to use and implement this model. This task included choosing the subjects to be taught using the analogies strategy and the Treagust model, identifying procedural objectives to teach the selected subjects, determining the time distribution for the classes of the selected subjects, identifying the tools and means required for each class, making a progress plan for the study, and identifying the various stages of teaching that would be required using the analogies strategy and the evaluation questions.

Figure 2. Clown: Change in Size, Shape, and Colour of the Clown

The Motivation towards Learning Science Scale was applied to achieve the study objectives and answer the second research question. This tool comprises 36 items centred on four elements: the self-esteem subscales, the value of learning science subscales, the performance subscales, and the achievement subscales. The students were asked to rate various statements using a Likert scale with the following five points: Strongly agree / Agree / Not sure / Disagree / Strongly disagree. The researcher created 36 items, which were then reviewed by a panel of professors and associate professors of science education. The reviewers assessed whether the items had appropriate linguistic phrasing, were scientifically accurate, and were suitable for the developmental stage of the participants. All items obtained a greater than 93% acceptance rate from the panel and were therefore retained.

The Kuder-Richardson Formula 20 (KR20), which is utilised for objects with varying levels of complexity, gauges the dependability of a test with binary variables (i.e., right or wrong answers). This formula should only be employed if each question has a correct answer. The internal consistency of the achievement test was calculated using the Pearson correlation coefficient. The values of the correlation coefficient ranged between 0.444 and 0.717. Content validity was checked by having a panel of experts review the suitability of each item for measuring the assigned behavioural objective. All items were deemed satisfactory.

In the Motivation for Learning Science Scale, the internal consistency values of the self-esteem subscale ranged between 0.396 and 0.873; the internal consistency values of the value of learning science subscale ranged between 0.396 and 0.873; the internal consistency values of the performance subscale ranged between 0.392 and 0.690; the internal consistency values for the achievement subscale ranged between 0.530 and 0.784. Cronbach'salpha (α) was utilised using the scores of 18 students to compute the reliability of the Motivation Scale (which consisted of 36 items). The values of Cronbach'salpha for the subscales were as follows: 0.866 for self-esteem, 0.882 for the value of learning science, 0.766 for performance, and 0.887 for achievement. The alpha for the total score of the scale reached 0.842. These data indicated that the scale had adequate validity and reliability.

RESULTS AND DISCUSSION

The overall results indicated that the programme effectively improved the development of students' science-based ideas. There was a significant difference between the mean scores of the pre-and post-learning measurements at the 0.01 level in the MCQ test in favour of the post-learning measurement. This significant difference could be attributed to the various activities and techniques adopted in the programme sessions.

Table 1. Results of the Mann-Whitney Test of Difference between the Pre- and Post-Learning Measurement Using the Achievement Test

Achievement Test	N	Mean Rank	Sum Of Ranks	Mann-Whitney U	Z Value	P-Value
Pre-learning	13	9.58	124.50	33.50	2.63	.009
Post-learning	13	17.42	226.50			

There are statistically significant differences between the pre-and post-learning measurements in the dimensions of self-esteem, performance, and achievement; the only insignificant subscale was the value of learning science. Taken together, those findings reveal that the programme effectively improved students' overall score for science learning motivation; thus, the programme equipped students with the tools to be positively motivated to learn science.

Table 2. Results of the Wilcoxon Test of the Difference between the Pre- and Post-Learning Measurement of Science Learning Motivation

Science Learning Motivation	Test Time	N	Mean Rank	Sum Of Ranks	Wilcoxon W	Z value	P-value
Self-esteem	Pre-learning	13	8.96	116.5	116.50	3.04	.01
	Post-learning	13	18.04	234.5			
Value of learning science	Pre- learning	13	9.42	122.5	122.50	2.73	.069
	Post-learning	13	17.58	228.5			
Performance subscale	Pre- learning	13	9.54	124.0	124.00	2.67	.01
	Post-learning	13	17.46	227.0			
Achievement subscale	Pre- learning	13	10.81	140.5	140.50	1.82	.01
	Post-learning	13	16.91	210.5			
Total score	Pre- learning	13	7.81	101.5	101.50	3.8	.01
	Post-learning	13	19.19	249.5			

This research involved using analogies to teach science concepts to fifth-grade students and aimed to establish the effect of using the Treagust model when teaching on developing students' scientific ideas and their motivation to learn science subjects. This research found that the experimental group, which was taught lessons incorporating the Treagust model, showed significant improvement in their results on the test. This study showed a positive change in the Saudi students' attitudes regarding the course in terms of student-centred and teacher-centred analogy techniques. This result confirms the results of different studies, including the one by Kılıç and Topsakal (2011). They stated that both student groups demonstrated considerable differences when comparing pre-test results with post-test results concerning the students' academic achievements, conceptual understanding, and attitudes regarding science courses. However, some studies did not find any impact (Karadogu, 2007, cited by Kılıç&Topsakal, 2011).

Further, multiple studies concerning promoting academic accomplishment have emphasised implementing analogies when teaching (e.g., Dilber & Dugun, 2008; Genc, 2013), and their findings have also recommended analogy-based teaching. Similar to those studies, the present work found that the use of analogies did not significantly affect students' attitudes toward learning science; however, this study shows that the use of analogies can lead to enhanced student engagement with and communication within the subject. It has been found that students who are not well-acquainted with scientific language find the familiar language of analogies easier to use to communicate about the concept being learned. Rahayu and Sutrisno (2019) stated that analogy is vital in chemistry learning. Most students frequently use analogies in their classes to explain complex concepts. Students find analogies entertaining as well as helpful in understanding course information. The students stated that an analogy could be applied in the learning process when it is derived from objects or events in their environment and is thus easier to remember. These results can be significant for the policymakers in the Ministry of Saudi Education regarding the textbooks, including suitable examples, tasks, and information that further analogical thinking.

Notably, it is essential for the following to be kept in mind while conducting such an evaluation: the extent of novelty, how complex the topics at hand are, and students' pre-existing knowledge concerning the topic (Treagust et al., 1998). Since many science concepts are dissimilar to any personal experiences students may have had in everyday life, science students often face challenges in comprehending complex concepts at a qualitative level (Chiu, 2000). Analogies can be used to address this issue and to allow students to reach an understanding of these complex topics (Dilber & Dugun, 2008). Indeed, Genc (2013) has reported that students regard the use of the analogy technique within lessons as helpful and that it allows for long-term learning. Science teachers can use analogies to improve students' grasp of the subject and students' ability to make links within the subject.

According to Ugur et al. (2012), it is necessary for science teachers to thoroughly understand the struggles their students may face when learning science concepts in order to produce effective learning. Many studies dealing with analogy use recommend that students produce their own analogies (Şahin et al., 2001). However, in order for the utilised analogies to pay off, significant analogy interpretation is necessary whenever they are found within textbooks (Duit & Glynn, 1996); indeed, according to Holyoak (2012), students will need constant high-level guidance from teachers in order to grasp the topic at hand fully. The use of analogies is a cognitive construct reinforced by using related analogies.

In addition, teachers should motivate students to create their analogies while being cautious. If students have a solid understanding of science concepts and a detailed understanding of the similarities and differences between the concept and the analogy, they can use this understanding to explore different ideas in different areas of study (Genc, 2013). Further research should focus on how the analogy strategy in teaching can affect different types of thinking, such as scientific and critical thinking. More research is also required on the impact of the analogy strategy on students' higher-level achievements, such as on the innovative thinking skills of gifted students.

Concerning the issue of professors' unwillingness to implement analogies while teaching their students, Maharaj-Sharma & Sharma (2015) pointed out that this un-cooperation may be a result of their mental constructs concerning what an effective education entails: they will not have been taught using analogies during their personal learning experiences, and so they may feel that it is unnecessary—or, perhaps, that they would not be well-equipped enough to—to implement such a strategy. Either way, this current research strongly advocates the use of analogical models within the Saudi Arabian classroom setting, assuming science teachers in the education region receive sufficient training when implementing such tactics.

CONCLUSION

Analogies have played a vital role in scientific development and science education. They have been used to create new scientific concepts and understand and explain abstract scientific concepts. One purpose of teaching with analogies is that the students will learn about a new object of study, a target domain, by comparison with another familiar source domain. This research found that the experimental group, which was taught lessons incorporating the Treagust model, showed significant improvement in their results on the test. Hence, the Treagust Model would be highly beneficial within the classroom context when it comes to tackling the problems currently present when teaching learners science subjects, as well as increasing students' general enthusiasm when it comes to learning. As a result of this conclusion, it is clear that the present investigation must explore the impact of this strategy in terms of growing students' grasp of scientific concepts and enthusiasm for learning within Saudi Arabian primary schools.

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