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The Effectiveness of the 4MAT Teaching Approach in Enhancing Conceptions of Electricity in Physics for Female Students in the Kingdom of Saudi Arabia

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ABSTRACT

This study sought to examine the impacts of the application of the McCarthy Model (4MAT) teaching approach in enhancing seventh-grade female students' conceptions of electricity in physics. The study sample comprised a total of 41 female students, who were selected from two schools located in the Kingdom of Saudi Arabia's city of Aljouf. The sample was divided into two groups, comprising 20 and 21 students in the experimental and control groups, respectively. The students in the experimental group were taught the science content through the 4MAT teaching approach, while students in the control group were taught with a more traditional approach of teaching. In order to attain the study objectives, two different study tools were designed, a teacher guide centered on the 4MAT teaching approach and a knowledge test concerning the physics conceptions of electricity. The findings showed that statistically significant differences were observed in enhancing the conceptions of electricity in physics between the experimental group and the control group, with students in the experimental group found to perform better than students in the control group.

Keywords: Electricity, 4MAT teaching method, misconceptions, seventh-grade students, physics teaching.

INTRODUCTION

Concepts of physics are the key foundation upon which the curricula of physics across all educational levels are built. Physics concepts are not considered merely a learning aspect, but also a critical focus upon which all curricula of physics are focused. The learning of physics concepts, as displayed by students, is fundamental since learners' development in this field is one of the most critical stipulations when it comes to enhancing understanding of organized scientific knowledge, including the laws, principles, and theories. This provides vital contributions to the overall interpretation of many different natural phenomena and further aids students in answering questions with a physics nature.

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Through examining prior works in this area (e.g., Wiser & Smith, 2008), it would seem that there are a number of identified problems when it comes to students' understanding of physics concepts. Such issues in this regard can be seen through the failure of learners to comprehend what is being taught and studied, and acknowledge and identify links between taught physics subjects and learners' life. Additionally, issues include problems in providing students with opportunities to effectively involve in learning, thus resulting in breakdowns in learners' understanding with an emphasis on memorization rather than meaningful understanding.

Accordingly, physics is recognized as a difficult science subject for students. In this vein, it is noted by Koba and Mitchell (2011) that there are various reasons underpinning the belief that (a) physics is difficult to learn, (b) physics contain such concepts tend to be abstract, (c) the systems inherent in physics are complicated, (d) the previously held knowledge of learners is somewhat restricted, (e) and students can suffer from misconceptions. Physics is known as one of the subjects where the knowledge of students can be seen to decline as a result of students' negative attitudes. There are also other reasons that can cause such a decline, including dependency on the memorization of information without establishing a clear association with learners' practical life, the problems encountered by learners in perceiving and understanding concepts of physics, and memorization of concepts amongst learners and corresponding application of a classic approach lacking creativity and understanding in overcoming questions and issues in the physics area.

When implementing teaching methods in educational settings, teachers are seen to depend on more conventional approaches including narration, dictation, and imposing the minds of learners with content, in addition to reducing scientific thinking and explanation of concepts. This can result in the presence of negative patterns and aversion of learners towards learning physics. As such, there is much value and importance to be acknowledged in the implementation of effective teaching methods in the field of physics through ensuring the active participation of students and assisting students in developing conceptual understanding. As one of the effective teaching methods, the 4 Mode Applications Techniques (4MAT) is recognized as a learner-focused approach arranging learning in line with the learners' individual needs. Importantly, meaningful learning is facilitated through this effective model by directing learners towards cooperative learning and relational thinking (Ahuja & Jahangiri, 2003).

The 4MAT method is a teaching model based on the constructivist theory in which different strategies are gathered together. Thanks to this integrated combination of techniques, educators have the opportunity to establish their unique approaches, which can motivate students through creating durable, immersive and supportive learning environments (Merrill, 2001; Raija, 2001, as cited in Pruekpramool, 2011). Research has shown that an integrated system is more efficient at providing learners with greater opportunities to grasp subject matters than utilizing segregated methods (Beane, 2016; Czerniak & Johnson, 2014). Moreover, an asset of the 4MAT method is its ability to allow for varied learning and knowledge processing capabilities demonstrated through the application of interactive exercises such as visualization, theoretical awareness, modeling and showcases of creativity. The 4MAT teaching model can be adopted by teachers, predominantly through the rationalization that aids them in completing cooperative activities. Accordingly, in order to ensure the development of a strong interdisciplinary initiative, as an integrated teaching approach, this model's application is effective and includes various benefits (Blair & Judah, 1990).

4MAT Teaching Method

The 4MAT teaching method was originally developed in line with the underpinning of constructivism and defined as a teaching approach by McCarthy (1987). This model presents an instructional system that assists teachers in the design of study units that deal with learning styles. The model can be applied to any content area and utilized across all grade levels. In reference to the McCarthy(1987) model, the 4MAT system comprises four different learning styles centered on acknowledging and processing received information. The first type of learner is predominantly focused on personal meaning (experience phase), while the second type of learner is focused more on the details as they lead to conceptual understanding (commonly referred to as the conceptualization phase). The third type of learner seeks to determine how things work and focuses attention on the more practical side of concepts (recognized as the applying phase). The fourth type of learner is focused on enhancement and self-discovery, which is known to make up the creating phase. The cycle offered in the 4MAT system comprises eight different activities, spanning across the four different types of learning, making use of both left- and right-brain processing procedures across all quadrants (Tatar & Dekici, 2009). The teaching model of 4MAT can be described as a combined teaching method, which facilitates various teaching approaches and techniques centered on the constructivist theory. The model further motivates learners to arrive at their perceptions and understandings. Through the adoption of various teaching methods as in an integrated way, learning becomes more supportive and interesting, and thereby facilitates permanency (Merrill, 2001; Raija, 2001, as cited in Pruekpramool, 2011). The majority of learners have a preference in learning across all four methods, which incurs restrictions in terms of developing other learning tools. The 4MAT teaching method, however, has the benefit of enabling all learners to adopt their own learning styles; therefore, teaching environments need to be presented in such a way to meet learners' learning styles (Ergin & Atasoy, 2013). As an example, some learners are better at learning science through more solid activities such as the completion of experiments, whereas others might prefer more abstract mental activities. Conversely, some students demonstrate better learning when making individual presentations of a project, whereas other students may prefer approaches involving group learning. In the view of Morris and McCarthy (1990), every student can be involved in varying stages of the learning cycle.

Key learning styles can be categorized into four different groups, analytic, commonsense, dynamic and innovative. Students can implement various learning methods in their learning. For example, an analytic learner might show a preference for what experts think so that the learner learns by thinking through ideas; a common sense learner can seek to determine how things work, therefore, learns with the adoption of a hands-on approach; a dynamic learner might be more inclined to complete a number of different activities, hence, learns by focusing on self-discovery; and lastly, an innovative learner requires personal involvement, thus, learns through social interaction (McCarthy, 1980, as cited in Wilkerson & White, 1988).

Research on the Influence of the 4MAT Teaching Method in Science Education

A research study by Ergin and Atasoy (2013) sought to determine the misconceptions of learners in electricity and the influence of the 4MAT teaching method on learners' misconceptions. In order to identify those students holding misconceptions about electricity, a non-equivalent pre-test–post-test control group design was implemented alongside a three-level test, utilizing a sample comprising 100 ninth-grade students. The researchers found that students have several misconceptions, including attenuation model, current flow as water flow, current potential difference confusion, empirical rule model, local reasoning, power

supply as a constant current source model, sequential reasoning, and short circuit misconception. It was further noted that the frequency identified across the majority of the misconceptions declined following innovation application.

The effects of the 4MAT learning framework on academic attainments of seventh-grade learners were analyzed in a study by Aktas and Bilgin (2015), with further emphasis on establishing motivation for learners towards the 'Particulate Nature of Matter' unit and identifying the views of students on the 4MAT approach. The study sample was a total of 235 Turkish students. Students' opinions in the experimental groups on the 4MAT framework were determined through open-ended questions following the implementation. The results of the study showed that the 4MAT model implementation enhanced the overall participation and motivation of students in the lesson. Furthermore, students found lessons more enjoyable and increased their self-confidence. Alongside such positive viewpoints, however, some learners highlighted that the approach was time-consuming, they did not feel motivated, and the subject was not more understandable through the use of the system. Nonetheless, the 4MAT model was seen as more effective than the traditional method in improving motivation and academic achievement.

The study carried out by Alhadaybeh and Ambusaedy (2016) explored the influence of applying the 4MAT model in the development of reflective thinking and science achievement across a sample of 55 sixth-grade female students from two different schools located in Dakhiliyah Governorate. The findings of the study showed that, when examining the means of the experimental and control groups, there were statistically significant differences in all reflective thinking skills and science achievement test scores, indicating the experimental group performing better.

Azam (2016) investigated effectiveness associated with the adoption of the 4MAT teaching method in terms of acquiring and understanding scientific concepts, and learning and applying thinking styles with a sample of 59 eighth-grade students. The researcher determined the overall effectiveness of applying the 4MAT in acquiring scientific concepts in fossils and protection of species topic from extinction unit underwent restructuring through the 4MAT system. However, the researcher could not identify learning and applying thinking styles.

Ghazal(2016) investigated the effects associated with the adoption of the 4MAT teaching method in developing seventh-grade female students' scientific thinking skills and concepts. The sample comprised 61 individuals in total. The findings emphasized a statistical significance in terms of the differences between students' mean scores in the experimental group and those in the control group, with the experimental group showing a better performance. Importantly, the adoption of the 4MAT system was identified as valuable in developing scientific thinking skills and concepts in the teaching of other subjects.

The effects of applying the 4MAT model in terms of developing understanding in biological concepts and retention for female learners in biology classes at a secondary educational level were examined in a study by Jassim, Mahdi, and Kareem (2016). The participants involved in the study were 83 students. The researchers used an experimental design with two equivalent groups, experimental and control groups. Importantly, both of the groups were equivalent, from a statistical point of view, specifically concerning factors such as age, intelligence, previous knowledge, previous information, and parents' education. The results of the study revealed that the experimental group showed superiority. Accordingly, the findings suggest that biology teachers acknowledge and consider implementing more conventional styles and approaches and consider using the styles and approaches in their teaching in colleges.

Tezcan and Güvenç (2017) examined the effects of the 4MAT system and Whole Brain Model to determine their influence on academic attainment in science and compare the effects of the 4MAT system and Whole Brain Model with the effects of inquiry-based instruction.

The design of the study was a static group pre-test–post-test design. Researchers determined that, when contrasting the 4MAT Teaching Model with the Whole Brain Model, the inquiry-based instruction was found as more effective in terms of enhancing students' academic achievement. Nonetheless, it was further established that the 4MAT Teaching Model and Whole Brain Model had effects on academic attainment in specific fields of science, but such effects did not differ from the effect of inquiry-based instruction. Furthermore, it was also determined that the influence of the 4MAT Teaching Model and Whole Brain Model on academic achievement in science did not show different outcomes in students' learning styles. In contrast, it was found that inquiry-based instruction did not facilitate students' academic achievements when the 4MAT Teaching and Whole Brain Models adopted a more divergent learning approach.

There has been limited research on the 4MAT model in Saudi Arabia, meaning little evidence exists in broadening female learners' understanding of topics in physics including electricity. The subject appears to be an unpopular one, with girls showing a demonstrable preference for biology (Britner, 2008; Osborne & Collins, 2001) and a greater interest in more aesthetic topics such as animals and nutrition. According to Brickhouse, Lowery, and Schultz (2000), female learners immerse themselves in scientific learning in ways that might differ vastly from educational establishments' prevailing and traditional notions of gender. This remains a crucial topic because students' preferences for potential science-related careers can be shaped by schools' stances on gender in mathematics and science. Furthermore, factors such as social synergy and practical experience in an educational environment have been found to influence girls' dispositions toward the scientific disciplines (Aldahmash, Mansour, Alshamrani, & Almohi, 2016; Dawson, 2000).

Özmen (2011) found that there are three reasons for this disparity. Firstly, scientific topics can be considered abstract. Secondly, everyday words are often loaded with different meanings. Finally, there is a shortage of image skills, and learners sometimes lack prior knowledge of subjects. The sensitivity of the 4MAT teaching method to students' requirements is one of its great strengths, with a learning environment that is enhanced through the use of worksheets, experiments and sample cases. The 4MAT approach incorporates well-organized instructional methods and offers an improvement on the traditional curriculum in dealing with misinterpretations. According to Ergin (2011), the diversity of pupils' life experiences, learning styles and brain hemispheres is taken into account through the implementation of programs that reflect these differences. Furthermore, thanks to the provision of continuous scientific discovery in addition to conceptual discussions and assessments, learners are put in a position where they can challenge their preconceptions.

The Misconceptions of Students in Electricity in Physics

Electricity is recognized as a unique concept that individuals are exposed on a day-to-day basis (Asoko, 2002). Nonetheless, not being able to see what occurs when there is a flow of electron current through a circuit causes problems in developing understanding (Çepni & Keleş, 2006). It has been established in the study of Osborne (1983) that students have four different frameworks concerned with what the current is and how the current is generated. The models are the unipolar model, cashing current model, current consumption model, and the direct current model. In the work of Borges and Gilbert (1999), four different frameworks of electricity were defined across the sample, including electricity as flow, electricity as opposing currents, electricity as moving charges, and electricity as a field phenomenon.

Accordingly, it was outlined in the study of Çepni and Keleş (2006) that Turkish learners hold a number of different misconceptions in electric circuits. Furthermore, it is also identified that Model A, the unipolar model, achieved more acceptance across the fifth-grade

students (Group 1), as well as half of the students in ninth-grade (Group 3), developed knowledge of electric circuits as shown in Model C, the current consumed model. Moreover, the study carried out by Küçüközer and Kocakülah (2007) determined that the most valuable results identified in the study were the misconceptions including the idea of 'no bulb lights on if the switch is off,' notably explained through the use of more colloquial, and the idea that 'bulbs connected in parallel give better light than those connected in series'as a result of prior teachings. In addition, other misconceptions identified amongst the Turkish learners were included 'batteries are constant current sources' and 'the consumption of current.' Scholars highlighted the most commonly encountered findings achieved throughout the course of the study were students' misconceptions pertaining to simple electric circuits included current as a concept, interchangeable use of different concepts without considering their differences, and current as coming from the (+) pole of the battery and entering the bulb, at which point it is consumed to light the bulb, which is notably not influenced by the second wire linked between the (-) pole and itself. Furthermore, additional misconceptions included (a) the current as coming from both of the battery's poles and clashing in the bulb, (b) the current being equally divided across all of the parallel circuit lines, (c) a change prior to the bulb affecting the overall brightness of the bulb in the circuit connected in series although the same bulb is not affected by any in-circuit change, and (d) batteries are recognized as being constant sources of current. It is noted in the study by Cooke and Howard (2014) that young children could potentially hold the view that (1) electricity is a material that can be seen and held, which is housed inside the battery, (2) electricity is a material that travels to a bulb, (3) the bulb uses up energy, and (4) the greater distance between a bulb and battery, the less intensity of light. In this regard, it is further noted by Cooke and Howard (2014) that when children begin to build diagrams with more than one component.

The children might then start to believe that, when there are two bulbs, the light will be brighter for the first bulb, with the first wire using up electricity first before the remaining electricity reaches the second bulb. Children can often have set conceptions or misconceptions about scientific subjects (Kind & Taber, 2005). Therefore, a vital facet of teaching in schools is to determine and examine alternative viewpoints before creating learning environments which are better designed to overcome misunderstandings than the traditional and somewhat more challenging method (Driver & Bell, 1986; Driver, 1989, as cited in Ergin & Atasoy, 2013). Moreover, unless children overcome, these misconceptions can also have further negative implications because of their potential to obstruct the learning and comprehension of scientific concepts (Ergin & Atasoy, 2013). Abstract subjects are difficult for learners to comprehend on their own without sufficient support, an issue that may be exacerbated by teachers failing to take students' previous knowledge into account or not supporting subjects with suitable visual aids. For instance, students have shown various misconceptions about electricity (Çepni & Keles, 2006; Ergin & Atasoy, 2013). It has been demonstrated that the constructivist learning approach removes students' misconceptions by not only considering their prior engagement with the subject but also utilizing useful activities that help solidify their knowledge (Demirezen, 2010; Ergin&Atasoy, 2013; Küçüközer, 2004). The effect of the 4MAT model on changing misconceptions about electricity was compared with the traditional approach. Following the application of the 4MAT model, there was a significant decrease in misunderstanding terms such as 'attenuation model,' 'empirical rule model,' 'shared current model,' and 'short circuit.' This improved comprehension may be the result of the 4MAT model of the constructivist learning approach that offers opportunities to challenge misconceptions through the use of step-by-step planning and relevant activities (Ergin & Atasoy, 2013). Research on the 4MAT model has shown that it is a conventional teaching method to enhance the understanding of teaching in both electricity and physics in general.

Research Problem

On a global scale, science curricula and the various teaching approaches and techniques available have undergone many changes implemented to manage technical advances, scientific progress, and knowledge explosions in recent years. In an effort to deal with the global concern regarding teaching methods and the development of curricula, through the Ministry of Education, the Kingdom of Saudi Arabia (KSA) implemented, mathematics and science curricula development projects in the form of new science curricula. Such curricula are seen to partially rely on the translation of science books, as produced by McGraw-Hill Education R & D, undergoing adaptation across all educational levels in the KSA (Obeikan, 2012). This caused development, from comprehensive and qualitative perspectives, in science education and learning through the development of curricula, as well as teaching and evaluation approaches in line with international standards and modern educational theories.

Irrespective attention and actions towards the development of science curricula, a number of different educational research have suggested that curricula may have many different issues and obstacles warranting resolution, as concluded in a study by Albalawi (2012).The researcher emphasized that first and secondary grade physics books lack any form of triggers in terms of arousing the interest and motivation of learners. This lack of triggers can be an obstacle for teachers in the teaching curriculum. The findings of the study showed that low motivation could be identified amongst students in learning physics with poor levels of interest and motivation of learners.

The overall performance in basic abilities and knowledge displayed by secondary education graduates in the KSA was considered in the study of Alharby (2013). The researcher utilized a study sample of 41,440 students for abilities test, 25,012 students for attainment tests, and 24,212 students for abilities and attainment tests. The researcher concluded that for males and females, the measured skills in the attainment tests of biology, chemistry, physics, English, and mathematics were significantly low with such a decline seen to increase in the knowledge skills warranting high-order thinking skills. The scholar noted that insight into the application of skills required by the physics curricula were the lowest skills of students.

Albalawi (2012) further highlighted that there are a number of different obstructing issues facing physics teachers as a result of their poor knowledge of most appropriate and effective techniques and methods of teaching. It is common for learners to prefer memorization techniques as opposed to developing an overall understating of the subject at hand. Moreover, it is also common for learners to adopt ‘alternative concepts’ or even ‘wrong concepts’. Teachers in the majority of situations may choose to disregard this adaptation, which can ultimately result in negative effects by hindering the learning from developing a more comprehensive insight into more practical concepts.

Importantly, 4MAT teaching method implementation with the aim of presenting and teaching curriculum concepts has been recognized as valuable and meaningful as this can be seen through its gradual progression through various stages and teaching of concepts. In this vein, it is essential that students are well-positioned to gain comprehensive insights into subjects as a whole rather than becoming negative recipients of the information.

In the mind of such an objective, students need to be actively engaged in meaningful and interesting learning activities. This is fundamental if interest and motivation need to be enhanced. Furthermore, there is a need for learners and students to actively develop an understanding of the physical world. This understanding can be developed through the application of scientific frameworks to explain, describe, control, and estimate physics phenomena. For this purpose, this study seeks to provide answers to the following questions:

1. What are the effects stemming from more conventional teaching approaches when it comes to enhancing the conceptions of electricity in the teaching of physics amongst female learners in the Kingdom of Saudi Arabia?
2. What are the effects stemming from the 4MAT teaching method in terms of enhancing the conceptions of electricity in the teaching of physics amongst female learners in the Kingdom of Saudi Arabia?

METHODS

In this study, a quasi-experimental approach was used since the main purpose of the study is centered on examining the overall effectiveness associated with the 4MAT teaching method in teaching Saudi female students about the electricity unit to improve conceptions of physics. Notably, this study occurred in the second term of 2018.

a) General Background

This study was carried out in the city of Aljouf in the KSA, which provided the location for the sampling of schools and female students. In terms of the city, Aljouf is recognized as being comparable to other cities in the KSA with comparable cultural aspects. This means that another region in the KSA can be chosen to replicate this study to compare findings with another representative sample. This study was implemented with a quasi-experimental method in line with the design of the control and experimental groups. This was done in order to determine the overall effectiveness of the 4MAT teaching method in line with enhancing physics conceptions of electricity amongst female students in the KSA.

b) The Study Group

The study was completed with the use of a sample comprising a total of 41 seventh-grade female students, who were randomly chosen from two different middle schools in the north of the KSA. One of the schools provided the sample for the control group (e.g., 21 female students), while the other school provided the sample for the experimental group (e.g., 20 female students). The participants were recruited in an ethical way, with attention directed towards ensuring adherence to ethical guidelines, such as through obtaining letters of consent from the parents of the students. Furthermore, the names of the schools were changed to ensure the participants' identities were hidden. Importantly, the decision to recruit only students from seventh-grade was made in line with the fact that Saudi science textbooks present the 'Electricity' unit at this level.

c) Treatment

In the control group, the electricity unit was taught with the use of a traditional textbook as provided by the Ministry of Education in the KSA for students in seventh-grade. Through such an approach to teaching, the Saudi science teachers directed their attention towards communicating only scientific information to their learners (Alanazi, 2017). Accordingly, the learners were considered to be empty, with the teachers adopting the approach of filling their minds with new information. Essentially, the learners were considered to be objects to be acted upon as opposed to being involved, actively thinking subjects involved in the educational process. Furthermore, there was a tendency for them to implement what is known to be the 'chalk and talk' approach to teaching in which students would direct their time

towards listening to the teacher and taking notes in line with what was written with the board rather than communicating or discussing their opinions and views with the class. After the lessons, the teacher would ask one or two questions in order to evaluate the overall understanding. Nonetheless, should the learners not understand, the teacher would not provide the lesson again. In addition, the focus of the teacher was also centered on achieving improvements in the performance of good students, which warranted minimal work in contrast to directing attention to those less able students who arguably would benefit more from the focus. The learners were provided with positive feedback and good support whenever there was a lack of confidence in completing activities assigned by the teacher. Importantly, the teacher was more likely to give her time towards what they would teach as opposed to what learners should understand and gain knowledge at the end of the lesson (Alanazi, 2017).

At the same time, in the experimental group, teaching was delivered through the 4MAT teaching approach, with the steps and features in the electricity unit recognized as spanning two subjects, electric current and electric circuits. Importantly, the second of these can be seen as described below in the form of an example.

First Phase: Experience(10 Minutes)

- Learner: As was communicated in the prior lesson, we have come to understand electricity in relation to conductive and non-conducive materials, as well as understand the electric field, electrostatic charge, and the movement of electrons in solid materials.
- We have also come to determine the electric current and how it flows in a closed conductive circle, referred to as the electric circuit. This highlights voltage as being a measurement of the possible energy of electricity, responsible for the movement of electrons in the electric circuit. We also established that a volt is the measurement unit and that the electric resistance refers to the problem of measuring electrons, flow through materials with the conversion of electricity into light and thermal energy at the hands of electrons.
- Learner: Consider for a moment the switches on the classroom walls, and ask yourself why the lights turn off when we close the switch. Can you think about the electric circuit and how the connection method might function? Are you able to create a simple layout of the connecting and linking method?

Second Phase: Conceptualizing (15 Minutes)

- Learner: Should you or someone close to you want to buy an electric tool, such as a coffee maker or hair dryer, for example, you could look into whether or not it is suitable for your home with its voltage and your own power outlet. Think about what these things mean and how the overall efficiency of the device in terms of its operation may be affected.
- As emphasized in Ohm’s Law, should there be an increase in the voltage within an electric circuit, there would then be an increase in current the same way as a high-speed flow of water from a water bucket held at a height. Should the voltage not change across the circuit, there would then be a decline in the current as a result of increased resistance.
- In this section, Ohm’s Law is explained by the teacher regarding its mathematical relationship with the learners aiding in solving simple questions in the application of Ohm’s Law and the way in which one of the variables should be calculated with the given variables.

- The teacher then affords the lesson concepts in an effort to cement the concepts taught. The teacher provides the learners with the explanation that there are two different approaches to facilitate linking together electric circuits, namely through the use of parallel and series connections.
- The teacher then progresses forward by describing parallel and series connections, which is done by providing diagrams, with the learners then asked to estimate the two methods' differences.
- The teacher provides the learners with the explanation that there is differentiation in terms of the number of courses in which electric current flows in the circuits, with differences in line with whether or not such circuits may be linked through series or parallel circuits.
- Students are given direction by the teacher in regard to the way in which the electric circuits and their application in buildings may be safeguarded.
- The learners are provided with photocopies of electricity bills, thus enabling the teacher to provide learners with the skills needed in order to calculate electricity costs and accordingly link such information with daily consumption.
- The learners are assisted in establishing safety and protection approaches in the use of electricity, and in establishing the risks associated with thunder, electric shocks, and rain.
- The teacher described and detailed the scientific definitions on the blackboard by requiring students to note these in their books.
- The student is seen to progress through the experience stage through the conceptualizing stage, being facilitated by the observing teacher. During this stage, learners are provided with the information and concepts deemed important, and learners encouraged by the teacher to examine and complete analysis of the data and accordingly form concepts.

Third Phase: Applying (10 Minutes):

- A set of lesson materials are provided by the teacher, comprising connection wires, a notes table, batteries, and some small lamps.
- The learners are asked to examine the equipment.
- The learners are then asked how they can switch on one lamp through the connection of an electric circuit and, the learners subsequently were asked to add an additional lamp.
- The learners are then asked to connect the electric circuit of two lamps via a number of different approaches and to accordingly make notes.
- The learners are seen to progress through from conceptualizing to application. Throughout this stage, ordinary learners are seen to exhibit good performance, which represents the practical aspect of science. In this stage, the teacher is charged with delivering the necessary materials and tools, and accordingly providing the chance for learners to involve themselves in practical experiments. Follow-up work is carried out by the teacher with students provided with any necessary guidance.

Fourth Phase: Creating (5 Minutes):

- Throughout the creating stage, the learners progress through tangible experiences, and accordingly learn to associate their knowledge with their practical experience, which in turn allows them to develop concepts perfectly and apply these concepts in their day-to-day life. Throughout this stage, the teacher's role may be broken down into the points made as follows:

- The students are permitted to explore concepts and meanings from a practical standpoint.
- Students are challenged by reviewing what has been witnessed.
- The learners are challenged by posing the questions detailed below:
  1. What is the definition of an electric circuit?
  2. How would you define voltage?
  3. Can you identify the similarity between water flow and electric flow?
  4. What comparison would you give for electricity in parallel and in series?
  5. What different electricity use methods would you see in homes, schools, and other locations?

The lesson was concluded by the teacher with an overview of the addressed concepts, as well as the approaches applied in terms of protecting electric circuits and safety procedures pertaining to electricity usage.

d) Tools and Procedures

Since the electricity unit was recognized through the provision of abstract concepts, there was the reconfiguration of the unit through the application of the 4MAT approach. This was achieved by establishing the general aims as highlighted by the system. Using this particular approach as a key method for teaching the electricity unit, various assisting methods and approaches (e.g., discussion and dialogue)were adopted. In addition to the activities and tools outlined for use, there was the development of a teacher manual to provide guidance when progressing through the unit with the use of the 4MAT approach. The guidance detailed an introduction providing an overview of the aims underpinning the manual, as well as the philosophy about the 4MAT method and scheme, and the teaching method as a whole.

Following the completion of the reformulation of the electricity unit, several experts were provided feedback regarding the applicability of the unit before the implementation. The experts suggested some changes in the suitability of the teaching model, its grammatical and scientific precision, presentation, and content organization. Changes were incorporated as recommended. Furthermore, following the completion of the teacher manual, the draft of the manual was sent to an expert group for feedback regarding the manual's compatibility with the formulation of the module and overall applicability. Changes were incorporated in line with the opinions and views of the experts. In addition, the initial form of the test was also sent to the experts to receive feedback for each question's compliance with behavioral objectives set, the scope suitability, correctness level in science and grammar, test instructions, clarity, and the degree of test applicability. Reliability was determined through the application of KR-20 (Kuder-Richardson) on the scores of 41 students. Following the completion of the students' test, the result of KR-20 was found as 0.85. Furthermore, test validity was determined and validated with five experienced science teachers and six professors in the field.

A total of 30 multiple-choice questions were included in the test (see Appendix 1). The researcher of this study completed the preparation of the scientific concepts test about electricity containing questions with objectives to measure students' development of knowledge of scientific concepts taught in the module in the experimental and control groups.

e) Data Analysis

The purpose of this study was to examine the implications of the 4MAT teaching approach in enhancing physics conceptions of electricity amongst female students in the KSA. Students in the experimental group compared with the control group in addition to a contrast between the dimensional and tribal measurements. Since a normal distribution was assumed, the sample was reasonable and randomly distributed, and homogenous variance was ensured. Using a t-test, the data were analyzed in order to represent the differences between the two groups through SPSS software (Version 20.0).

FINDINGS

In line with the t-tests, the quantitative results centered on determining the influence of the 4MAT teaching system in terms of enhancing the overall physics conceptions of electricity for female students in the KSA. The two samples' homogeneity was established before the implementation of the 4MAT method. Results of the t-test showed no statistically significant differences between the two groups to such a degree that homogeneity for the two groups would be indicated before intervention (see Table 1).

Table 1: *Differences between the averages of the experimental and control groups prior to the traditional teaching method and the 4MAT teaching method*

Statistics Group	N	Mean	Std. deviation	df	t	Sig.
Exper	20	10.10	1.29	39	0.08	0.39
Cntrl	21	10.05	2.71			

Table 2 indicates that a key difference can be identified between the tribal measurement averages before the adoption of the 4MAT teaching system and the following telemetric adoption. Results revealed that the experimental group was the preferred group for dimensional measurement. This shows that a positive effect can result from the use of the 4MAT method with the success of enhancing the conceptions of physics amongst learners.

Table 2: *T-test for significance between pre- and post-tests in the experimental group*

Statistics Variable	Sample size	Average	Std. deviation	Degrees of freedom	T- value	Significance
Pre	20	10.10	1.29	19	-34.66	0.0001
Post		27.35	1.53			

Table 3 indicates a statistically significant difference between tribal measurement averages before the adoption of the conventional teaching approach and the following telemetric adoption. Results revealed that the control group was identified as performing favorably in regards to the dimensional element. This shows that the conventional approach provides a positive effect on the success of enhancing physics conceptions of electricity for learners.

Table 3: *The significance of the t-test between pre- and post-tests in the control group*

Statistics Variable	Sample size	Average	Std. deviation	Degrees of freedom	T- value	Significance
Pre	21	10.05	2.71	20	-3.85	0.002
Post		13.52	4.02			

Table 4 shows that students with the 4MAT teaching approach achieved success, especially when considering that the experimental group was found to be more a function of the control group in the case of the telemetric measurement.

Table 4: *T-test for significance between the experimental and control groups in the post-test*

Statistics Group	N	Mean	Std. deviation	df	T	Sig.
Exper	20	27.35	1.53	39	14.41	0.0001
Cntrl	21	13.52	4.02			

Furthermore, the overall magnitude or strength associated with the interaction or key effect can be seen to be reflected by the eta-squared value, where such a value is identified as being the proportion of variance considered in the dependent variable by the independent variable highlighting the extent of the relationship between the dependent and independent variables.

Table 5: *Eta square value between pre- and post-tests in the experimental group*

Independent variable	Dependent variable	η2	Effect size
4MAT teaching	Improving psychical concepts	0.98	High

According to Cohen (1988) metric, the effect size is small forη2=.01, moderate effect size forη2=.06, and large effect size forη2=.14. Accordingly, it may be seen that the effect explains 15%, and more than the total variance of any independent variable on dependent variables is significant. In terms of the values for the eta square range, these were seen to span from 0 to +1.00. If values were found close to 1, this would suggest a stronger link. Furthermore, the eta square value between pre- and post-tests in the experimental group was η2= .98. On the other hand, the eta square value between pre- and post-tests in the control group was η2= .39, which suggests that the effect of the 4MAT teaching approach was more valuable and efficient than the conventional approach when it comes to enhancing Saudi female learners' conceptions of physics and electricity.

Table 6: *Eta square value between pre- and post-tests in the control group*

Independent variable	Dependent variable	η2	Effect size
Traditional teaching	Improving psychical concepts	835	High

DISCUSSION

The 4MAT teaching method system is shown various effects in terms of enhancing the physics-related conceptions about electricity as held by female learners in the KSA,

with such effects undergoing analysis in this work. The findings indicated that the method delivers positive results with the success of teaching comparing to traditional approaches. Previous related works carried out on other courses support the findings of this study. Prior studies demonstrated that the application of the 4MAT teaching method is a valuable support in both developing scientific thinking skills (Ghazal, 2016) and understanding of scientific concepts (Azam, 2016). Moreover, the 4MAT teaching method is seen to be a more effective method of improving motivation and achievement (Aktas & Bilgin, 2015). According to Ergin and Atasoy (2013), the 4MAT teaching method changed misconceptions about electricity.

As an example, in the study of Ghazal (2016), it was found that there were statistically significant differences in examining the mean scores of the 61 female students. Results showed that students in the experimental group documented higher scores than students in the control group in the test of scientific concepts. The adoption of the 4MAT teaching method has been recognized as valuable in terms of developing scientific concepts and scientific thinking in the teaching of other subjects. In addition, the effectiveness of using the 4MAT teaching method on developing understanding and insights into various scientific concepts and learning styles of students were explored in the study by Azam (2016). In addition, the study by Ergin and Atasoy (2013) noted that the majority of the circuit misconceptions declined following the adoption of the innovative approach. Moreover, a more significant decline was found in the experimental group, implying that the teaching method of 4MAT was more efficient and valuable in decreasing the rate of misconceptions when compared with the traditional method.

Accordingly, in the present study, the conclusion may be drawn that the 4MAT system of instruction is more valuable than the conventional approach since students can find opportunities to query their understanding through intensive conceptual conversation. In essence, it was found that the 4MAT teaching method enables key and significant learning and further encourages learners to adopt relational thinking and cooperative learning, as highlighted by Ahuja and Jahangiri (2003).

In the study of Albalawi (2012), it was noted that there are many critical issues facing physics teachers in the Saudi context due to the lack of teacher knowledge of suitable approaches and methods. Students in the KSA commonly memorize the targeted knowledge as opposed to understanding and developing knowledge. As such, there is a wealth of value to be derived from implementing effective approaches in teaching physics through positive adoption of Saudi learners' roles as the key emphasis and focal point of the educational process alongside assisting learners in developing conceptual knowledge.

Essentially, the 4MAT Teaching Model may be viewed as an integrated teaching system, facilitating various teaching approaches and techniques in line with the constructivist theory. Moreover, through the traditional curriculum, comparable activities can also be presented, which could potentially improve the physics conceptions of learners. Nonetheless, the 4MAT teaching method is regarded as more valuable when it comes to providing the teaching of concepts in an organized and well-considered way. Potential rationalizations for this could be that teachers provide instruction without taking into account the previous knowledge of the learner or otherwise not providing sufficient support with visual materials (Ergin & Atasoy, 2013). On the other hand, owing to the application of the 4MAT teaching method in this study, learners were facilitated in group work participation, and the use of approaches (e.g., discussion, question asking, and dialogue)were concerned with students at the forefront. Moreover, learners were further encouraged to consider how things could work and accordingly related knowledge to their practical experiences in such a way to develop concepts perfectly and adopting such concepts in their day-to-day lives.

Conclusion

In the present study, the researcher examined the 4MAT teaching method's effects in enhancing concepts of physics, specifically in electricity teaching. Following the implementation, a more significant decline was observed in the experimental group, thereby implying that the 4MAT teaching method was more valuable and effective than the conventional approach in terms of enhancing physics conceptions amongst Saudi female students. In line with the research findings, an examination into the effects of the 4MAT teaching method on other more complex areas of physics, including regular circular momentum and magnetism, could provide vital areas for further investigation. Moreover, the 4MAT teaching method application in the science education field could result in greater interest in the educational process, as well as greater dedication to learning and teaching. The effect of Saudi culture has also resulted in the Ministry of Saudi Education being broken down into two different systems, managed in relation to gender. Accordingly, it is recommended to carry out a comprehensive study to examine the effects of the 4MAT teaching method in both males and females' schools in the KSA with specific consideration to concepts of physics. This research study offers assistance to those schools, teachers, and the Ministry of Saudi Education policy-makers looking to develop the curriculum, and shows that the model should be utilized in students' learning. Additionally, in order to further measure the potential long-term impact of the 4MAT teaching method enhancing understanding of scientific concepts, it is necessary to replicate the method in similar and divergent study settings. Different subjects, such as physics, chemistry, and biology, should be assessed with a particular emphasis on the primary and secondary stages in Saudi schools. Importantly, more work is required in order to explore and determine the effects identified following the use of the 4MAT approaches in development types of thinking, including creative thinking, critical thinking, and reflective thinking. Moreover, different levels of students could be used as a sample.

REFERENCES

Ahuja, O. P., Lim-Teo, S. K., & Lee, P. Y. (1998). Mathematics teachers' perspective of their students' learning in traditional calculus and its teaching strategies. *Journal of the Korea Society of Mathematical Education: Research in Mathematical Education*, *2*(2), 89–108.

Ahuja, O. P., & Jahangiri, J. M. (2003). An integrated approach to teaching and learning college mathematics. *Journal of the Korea Society of Mathematical Education Series D:Research in Mathematical Education*, *7*(1), 11-24.

Alanazi, F.H. (2017). Effectiveness of the proposed training formative assessment programme and its impact on teaching style improvements of Saudi science teachers in Saudi Arabia. *Journal of Turkish Science Education*, *14* (1), 35-56.

Albalawy, F. (2012). *Evaluation of the physics textbook for the first scientific secondary grade in the Kingdom of Saudi Arabia and the problems that face students In its studying from perspective of teachers and educational supervisors*. Unpublished master's thesis, The University of Jordan, Amman, Jordan.

Aldahmash, A. H., Mansour, N. S., Alshamrani, S. M., & Almohi, S. (2016). An analysis of activities in Saudi Arabian middle school science textbooks and workbooks for the inclusion of essential features of inquiry. *Research in Science Education*, *46*(6), 879–900.

Alhadaybeh, E., & Ambusaedy, A. (2016). The effect of using McCarthy model in improving reflective thinking and science achievement for grade 6th basic female students. *Jordan Journal of Educational Sciences*, *12* (1), 1-15.

Alharby, K. (2013). The performance of secondary education graduates in the Kingdom of Saudi Arabia in basic cognitive abilities and skills. *Journal of Education and Psychology*, *41*(1),125-144.

Asoko, H. (2002). Developing conceptual understanding in primary science. *Cambridge Journal of Education*, *32*(2), 153-164.

Azam, M. (2016).*The effectiveness of using* McCarthy *model (4 MAT) in acquisition the scientific concepts and developing the learning and thinking styles for 8th grade students*. Retrieved fromhttps://www.minia.edu.eg/edu/images/Scientific-Journal/Fifth-volume-2016/Mahmoud-Ramadan.doc.

Beane, J. A. (2016). *Curriculum integration: Designing the core of democratic education*. Newyork, USA: Teachers College Press.

Blair, D., & Judah, S. S. (1990). Need a strong foundation for an interdisciplinary program? Try 4MAT! *Educational Leadership*, *48* (2), 37-38.

Borges, A. T., & Gilbert, J. K. (1999). Mental models of electricity. *International Journal of Science Education*, *21*(1), 95–117.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching, 37*(5), 441-458.

Britner, S. L. (2008). Motivation in high school science students: a comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching, 45*(8), 955- 970

Çepni, S., & Keleş, E. (2006). Turkish students' conceptions about the simple electric circuits. *International Journal of Science and Mathematics Education*, *4*(2), 269-291.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. New York, NY: Routledge Academic.

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 395–411). New York, NY: Routledge.

Dawson, C. (2000). Upper primary boys' and girls' interests in science: Have they changed since 1980? *International Journal of Science Education, 22* (6), 557–570.

Ergin, S. (2011). *Effects of the 4MAT instruction method on the achievement of high school students with different learning styles on the subjects of work, power and energy in physics education* (Unpublished doctoral dissertation). Gazi University Department of Physics Education, Ankara.

Ergin, S., & Atasoy, S. (2013). Comparative analysis of the effectiveness of 4MAT teaching method in removing pupils' physics misconceptions of electricity. *Journal of Baltic Science Education, 12*(6), 730-746.

Howard, C., & Cooke, V. (2014). *Practical ideas for teaching primary science*. Critical Publishing, Northwich.

Ghazal, R. (2016). *The effectiveness of using format (4MAT) system in developing the scientific concepts and thinking skills among seventh graders in Gaza*. Retrieved from http://library.iugaza.edu.ps/thesis/119485.pdf.

İdris, A., & İbrahim, B. (2015). The effect of the 4MAT learning model on the achievement and motivation of 7th grade students on the subject of particulate nature of matter and an examination of student opinions on the model. *Research in Science & Technological Education, 33*(1), 1-21.

Jassim, A., Mahdi, A., & Kareem, E. (2016).*The effect of using(4 MAT) model in acquiring biological concepts and their retention in female students of Second Intermediate Class*. Retrieved fromhttps://www.iasj.net/iasj?func=fulltext&aId=126067.

Kind, V., &Taber, K. S. (2005). *Science: teaching school subjects 11-19*. London: Routledge.

Koba S., & Mitchell T. C. (2011). *Hard-to-teach science concepts: A framework to support learners, grades 3–5*. NSTA PRESS, pp. 5-6.

Kucukozer, H., & Kocakulah, S. (2007). Secondary school students' misconceptions about simple electric circuits. *Journal of Turkish Science Education, 4* (1), 101-115.

McCarthy, B. (1987). What 4MAT training teaches us about staff development? *Educational Leadership,42* (7), 61-68.

Morris S., & McCarthy, B. (1990). *4MAT in action II: sample lesson plans for use with the 4MAT system*. Excel, Barrington.

Obeikan Education. (2012). *General information*. Retrieved from http://www.obeikaneducation.com/en/content/k-12-education.

Osborne, J., & Collins, S. (2001). Students' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education, 23* (5), 441-467.

Osborne, R. (1983). Towards modifying children's ideas about electric current. *Research in Science and Technological Education, 1* (1), 73-83.

Özmen, H. (2011). Turkish primary students' conceptions about the particulate nature of matter. *International Journal of Environmental & Science Education, 6*(1), 99-121.

Pruekpramool, C. (2011). The *development of the science of sound in traditional Thai musical instruments interdisciplinary course for non-science upper secondary school students by using integrated teaching approach* (Unpublished doctoral dissertation). Srinakharinwirot University, Bangkok, Thailand

Tatar, E., & Ramazan, D. (2009). The effect of the 4MAT method (learning styles and brain hemispheres) of instruction on achievement in mathematics. *International Journal of Mathematical Education in Science and Technology, 40*(8), 1027-1036.

Teczan,G., & Guvenz, H. (2017). The effects of 4MAT teaching and whole brain model on academic achievement in science. *Education and Science, 42*(192), 303-325.

Wilkerson, R.M. & White, K.P. (1988). Effects of the 4MAT system of instruction on student's achievement, retention and attitudes. *The Elementary School Journal, 88*(4), 357-368.

Wiser, M., & Smith, C. L. (2008). Learning and teaching about matter in grades K–8: When should the atomic–molecular theory be introduced? In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp.205–239). New York: Routledge.

Appendix 1: Sample of questions in the electricity module test

1-Electric charges generated on some objects for a temporary period of time, which are defined as:
a) mobile electricity b) electrical circuit c) electrical current d) static electricity

2-Similar electrical charges:

a) attraction b) repulsion c) not affected d) sometimes attractive sometimes repulsive

3-Copper wire is used in electrical installations in buildings because it:

a) conducts electricity and does not heat b) heats and thus transmits electricity more c) has a longer life to use d) because it is cheap

4-The shipment of objects is in its natural state

a) negative b) neutral c) positive d) do not carry electrical charges

5- Wool is fit when rubbed with plastic and charged positively because:

a) loss of positive charges b) loss of negative charges c) acquisition of positive charges d) acquisition of negative charges