Effect of 4MAT Model of Teaching on Achievement in Economics in Relation to Learning Styles

Dr. Kanwalpreet Kaur & Anjum Sharma***

Abstract

The present study aimed to analyse the effect of 4MAT model of teaching on achievement of the students in Economics having different learning styles. The study relied on a pre-test and post-test control group experimental research design. The sample comprised 160 students of 10+1 English medium private schools of Amritsar District, affiliated to Central Board of Secondary Education. The results showed that 4 MAT instructional strategy of teaching Economics was effective in comparison to conventional teaching strategy. Students having constructive learning style performed better in comparison to the students having reproducing learning style. The instructional strategy and learning styles interacted to produce a significant effect on the achievement of students in Economics.

Key Words: *4 MAT teaching model; 4 MAT teaching model based instructional strategies; Conventional teaching strategy; and Learning Styles.*

About authors:

** Assistant Professor, Institute of Educational Technology and Vocational Education, Panjab University, Chandigarh*

*** Research Scholar, Department of Education, Panjab University, Chandigarh*

Introduction:

Today, we find ourselves amidst the loud voices proclaiming diversity in the classroom and surely it is the talk of the town. All thanks to psychology for its interference in education that resulted in the phenomenon of individual differences. No two individuals, be it children born from the same parents and even the twins are not alike in terms of attitude, personality, intelligence, achievement, aptitude etc. This can be attributed to the fact that children develop at different rates. For sure these differences by birth are going to turn up in classrooms as well. So, it shall be injustice to expect that all the astute minds seated in a classroom are similar in terms of their learning, thinking, imagination or learning styles.

In such a scenario, the jobs of the teachers have become increasingly onerous, because preparing the students today to thrive in this competitive world is no easy task, hence putting the teachers in a difficult position; whereby they are not only expected to have a deeper understanding of the subject they teach but also to prepare the diverse learners in their class for the challenges of 21st century through so called quality education.

The universal acceptance has been given to the fact that yester years lecture – centric i.e. approach of one size fits all cannot groom all the students collectively for competitive era. As there is no single recipe to excellent teaching, some of our brilliant minds have been engaged in developing some neoteric teaching strategies, based on available theories of learning. The by – product for the same has been that, the nucleus of today's education has shifted from lecture method to learning by activity, learning by doing and incarnation of terms like collaborative learning, concept mapping, co – operative learning and various strategies and models of teaching.

In tune of this, many models of teaching have been developed to magnify creativity among the learners like, Inductive Thinking Model (Taba, 1966), Kaplan Model (1993), Synectics Model (Gorden, 1961) and 4 MAT Model (McCarthy, 1972). McCarthy's Four Mode Application Technique of teaching is one such approach that is specifically meant to cater the needs of different kinds of learners in a class and enhancing their creativity. 4MAT identifies four interrelated learning styles based on how individuals perceive and process new information. Its premise is that individuals learn primarily in one of the four different, but complementary ways based on how they perceive and process information (McCarthy & McCarthy, 2006).

4MAT stands for Four Mode Application Technique. The model has been designed by McCarthy in 1972. The conception of the model is grounded in the work of David Kolb, John Dewey

and Carl Jung in addition to the concept of Brain Hemisphericity (McCarthy, 1987).

Kolb's Experiential Learning theory works on two levels i.e. a four stage cycle of learning and four separate learning styles (Kolb, 1984). Another theory that contributes to the incarnation of the four mode application technique is hemispheric preference for learning. The present hour's research on educational brain implies that following exclusively one sided approach only fails to tap the learning capacity of whole brain. It is practically not possible to operate on exclusively with one side of brain. Both the brains are equally important in terms of whole brain functioning. Thus, when the works of all these educationists are pooled together in form of 8 steps of four mode application technique, it results in an excellent teaching strategy (McCarthy, 2006).

The process involved in 4 MAT takes into accounts all the learning styles in one cycle of learning process, which involves all learners' difference. (McCarthy, 1987). The process of 4 MAT technique is divided in to four quadrants, which are based upon Kolb's experiential learning style theory which further typically represents a four stage learning cycle. Here in, the learner touches all the bases i.e. concrete experience - (a new experience of situation is encountered, or a reinterpretation of existing experience); reflective observation (of the new experience, importance are laid on any inconsistencies between experience and understanding); abstract conceptualization (reflection gives rise to a new idea, or a modification of an existing abstract concept); and active experimentation (the learner applies them to the world around them to see what results). The details of each quadrant and its steps of 4MAT teaching model are summarised as follows:

Details of Quadrants of 4MAT Model of Teaching (McCarthy, 1990)	
Quadrant 1: Concrete Experience	
Step 1: Connect or Create an Experience	This is the foremost step that links the basic concept of the lesson to the learners in a personal and meaningful way.
Step 2: Examine or Reflect on the Experience	The teacher in this step can ask the learners to think about the experience and share it with others.
Quadrant 2: Reflective Observation	
Step 3: Image or integrate the observation into concepts	Here the teacher tries to synthesize the reflections from previous experiences
Step 4: Informing or Developing theories and concepts	The teacher here gives information about the concepts under study through various possible means like lecture, computer assisted instruction or charts.
Quadrant 3: Abstract Conceptualization	
Step 5: Practicing or using information practically.	The emphasis here shifts from acquisition and assimilation to testing and adaptation.
Step 6: Extending or Integrating material with Self	The teachers shall provide opportunity to students to develop their own applications which demonstrate that they have well understood and can apply the learnt concepts.
Quadrant 4: Active Experimentation	
Step 7: Refining or Analysing for usefulness or application	The learner now uses the information in creative way and moves beyond simple practice and reinforcement.
Step 8: Performing or Integrating application and experience	The learners finally perform the original example of their learning and share it with others

Kolb's learning theory sets out four distinct learning styles associated with these four patterned characteristic approaches to learning namely diverging, assimilating, converging and accommodating. The 4MAT model was built upon the above line of thought, recognising the differences in the way students learn and the way they process what they have learnt. So, the four types of learners categorised in 4 MAT are imaginative learners, analytic learners, common sense learners and dynamic learners (McCarthy, 2003). The 4MAT teaching model has a distinction from other learning styles theories and it takes into account all learning styles in one cycle of learning process, which involves all learners' difference (McCarthy, 1987).

The eventual aim of applying varied models and pedagogies of teaching is to study its impact on the academic achievement of students. Achievement can be stated to be the performance of an individual in a particular field up to a desired level. It is the level of a person's learning and his/ her ability to apply what s/he has learned in a given field of learning. Further academic achievement refers to the attained level of educational growth. In the literal sense of the term, academic achievement is the combination of two words academic and achievement that implies scholarly accomplishment.

Academic achievement refers to the degree or level of success or that of proficiency attained in some specific areas concerning scholastic or academic work (Oxford Advanced Learner's Dictionary, 2000). Academic achievement is the indicator of the student's level of acquired knowledge or skill, which has been gained as a result of training or experience. Thus, academic achievement implies achievement in distinct subjects or total scores of diverse subjects together. It is concerned with the quantity and quality of learning that resulted in a subject of study or group of subjects after a stipulated period of instruction (Ewumi, 2012)

Economics is a subject that integrates theoretical skills, calculation, graphs, tables and equation to answer questions. Students who took Economics need to use abstract thinking and apply Economic theories in their daily lives. Students too need to define complex ideas logically and fluently based on their understanding in this subject (Carol, Richard, Jenny & Ian, 2000). So, Economics is regarded as a difficult subject by many students, at the same time dull and boring by the others (Cadenas, 1999). According to an analysis of CBSE results for Class 12 done by the Hindustan Times, the subject had the highest failure rate between 2004 and 2015 and one in every five students who sat for a CBSE economics exam got failed in 2015 (Bhatia and Sharma, 2017). This necessitates that some innovative methods need to be incorporated by the teachers to make teaching and learning of economics more interesting and creative.

Each student has a different way of learning. Academic achievement of a learner is certainly influenced by his learning style. Since each student has a different learning style, so it necessitates to have an initial assessment related to differences in learning styles that need to be adjusted to the appropriate learning methods. The style of learning is a way to receive, process, remember and apply the information easily. Brown (2000) defined learning styles as the manner in which individuals perceive and process information in learning situations. He argued that learning style preference is one aspect of learning style, and refers to the choice of one learning situation or condition over another. Learning style is sometimes defined as the characteristic cognitive, affective, social, and physiological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (MacKeracher, 2004).

Student learning styles can be recognized among the learning styles of visual, auditory and kinaesthetic. Students with a visual learning style learn through what they see, students having auditory learning style learn through what they hear and kinaesthetic students learn through movement and touch. In the present study learning style inventory by Misra (2012) has been employed to categorise the students on the basis of their learning styles i.e. Reproducing learning style having Enactive reproducing, Figural reproducing and Verbal Reproducing learning styles together to mean; and Constructive learning style having Enactive constructive, Figural Constructive and verbal Constructive together to mean.

Bowers (1987) studied the effect of the 4MAT Model on achievement of students of class VI and revealed that the experimental group performed better than the control group. Winkerson and White (1988) reported the significant differences favouring the 4MAT group in terms of achievement scores and attitude of third grade students. Nancy and Bibbins (1993) studied the effects of the 4MAT Model of instruction on achievement of elementary children in music listening lessons and found that the 4 MAT instructional model offers a viable approach for listening.

The effects of the 4MAT system model of instruction on learning achievement of lower secondary school students was assessed and was revealed that students when taught with 4 MAT Model had higher achievement and attitude in science than the students who were taught using traditional method (Wichianmongkolkul, 2006). A review of the related literature indicated that 4MAT teaching model instructional strategies have positively influenced the academic achievement of the students in diverse subjects.

Objectives of the study

- To compare the achievement of students taught through 4MAT teaching model based instructional strategy and conventional teaching strategy in Economics.
- To study the achievement in Economics of students having different learning styles.
- To examine the interaction effect of 4MAT teaching model based instructional strategy and learning styles on achievement of students in Economics.

Hypotheses of the study

- There exists no significant difference in the achievement in Economics of students taught through 4MAT teaching model based instructional strategy and conventional teaching strategy.
- There exists no significant difference in the achievement in Economics of students having reproducing and constructive learning styles.
- There exists no significant interaction effect of 4MAT teaching model based instructional strategy and learning styles on the achievement of students in Economics.

Method and Procedure of the study

- **Sample:** The present study was conducted on a randomly selected sample of 160 students of XI grade from two English medium schools of Amritsar in Punjab affiliated to Central Board of Secondary Education. The two schools were randomly selected from the list of schools of Amritsar. The sample included 80 students from Shri Guru Harkrishan International Senior Secondary School, Ranjit Avenue, Amritsar and 80 students from S.L Bhavans Public School, Amritsar. Further, the intact sections were randomly selected out of two schools. Students were categorised on the basis of their learning styles by using Learning Style Inventory by Misra (2012). The students were divided into two groups having Reproducing Learning Style and Constructive Learning Style and those were randomly assigned as experimental and control groups.
- **Design:** The study relied on a pre-test and post-test control group experimental research design. In this study, instructional treatment i.e. 4MAT teaching model based instructional strategy was the independent variable; achievement in Economics was the dependent variables; and learning styles was the classifying variable which is studied at two levels viz. reproducing and constructive learning style. The experimental group was taught through 4MAT teaching model based instructional strategy, whereas, the control group was taught the same topics with conventional teaching strategy. The scores of dependent variables i.e. achievement in Economics were calculated as mean gain scores (difference in post-test scores and pre-test scores). In order to analyze the data, a 2x3 factorial analysis of variance was used.
- **Tools:** The following tools and techniques were used:
    - Instructional material based on 4MAT teaching model and conventional teaching strategy for teaching Economics was developed by the investigator.
    - Achievement test in Economics developed and standardised by the investigator.
    - Learning Style Inventory by Misra (2012)

- **Procedure:** After the selection of the sample and allocation of students to the two instructional strategies, the experiment was conducted in four phases**.** Firstly, the learning style inventory was administered in each school, in order to identify the learning styles of the students. Secondly, an achievement test in Economics as pre-test was administered to the students of both the experimental and control groups. Thirdly, the experimental group was taught through 4MAT teaching model based instructional strategy and control group was taught through conventional teaching strategy by the investigator. Fourthly, after the completion of the course, an achievement test in Economics was administered as post-test to the students of both the groups. The answer sheets were scored with the help of scoring key.

Analysis and Interpretation of the Results

The analysis of variance (2X3) factorial design was employed to compute the difference in mean gain scores of experimental and control group students on achievement in Economics and results are presented as follows:

Table 1: Summary of Analysis of Variance (2X3) Factorial Design

Source of variation	df	Sum of Squares	Mean Sum of Squares	F -Value
Instructional Strategy (A)	**1**	**342.22**	**342.22**	**41.86****
Learning Styles (B)	**1**	**122.5**	**122.5**	**14.98****
Interaction (AXB)	**1**	**41.025**	**9.025**	**5.018***
Error within treatment	**156**	**1275.35**	**8.175**	
Total	**160**	**6458.00**		

*Significant at 0.05 level of significance
**Significant at 0.01 level of significance

- **Instructional Strategy (A):** For the main effects of instructional strategy on achievement in Economics, from the table 1, it is clear that achievement in Economics of students taught through 4MAT teaching model based instructional strategy and conventional teaching strategy was found to be significantly different at 0.01 level of significance. Hence, the hypothesis stating that there exists no significant difference in the achievement in Economics of students taught through 4MAT teaching model based instructional strategy and conventional teaching strategy is rejected. The result indicated that the 4MAT teaching model based instructional strategy was more effective than that of the conventional teaching strategy.

- **Learning Styles (B):** For the main effects of learning styles on achievement in Economics, from table 1, it is evident that learning styles of students, viz reproducing and constructive was found to be significantly different at 0.01 level of significance. Hence, the hypothesis stating that there exists no significant difference in the achievement in Economics of students having different learning styles is rejected.

- **Interaction Effect (A X B):** It is clear from table 1, that F-ratio for the interaction between instructional strategy and learning styles (AXB) is 5.018, which was found to be significant at 0.05 level of significance. A significant F-value indicated that two variables i.e. instructional strategy and learning styles interacted to produce a significant effect on the achievement of students in Economics. So, the hypothesis stating that there exists no significant interaction effect of 4MAT teaching model based instructional strategy and learning styles on the achievement of students in Economics is rejected.

The F-ratio for main effects of instructional strategy (A), achievement motivation (B) and interaction effect (AXB) found to be significant, so, to ascertain the significance of difference between means of various combination groups, t-ratios were computed and results are presented in table 2

Table 2. t-ratio for different Combination Groups on Mean Gain Achievement Scores in Economics for difference in Instructional Strategy and Learning Styles

Groups	A_1B_1 Mean= 5.78 S.D.= 3.309 N= 40	A_1B_2 Mean= 8.00 S.D.= 2.631 N=40	A_2B_1 Mean=3.33 S.D.=2.546 N=40	A_2B_2 Mean=4.60 S.D.=2.889 N= 40
A_1B_1	---	3.329**	3.712**	1.692
A_1B_2		---	8.076**	5.503**
A_2B_1			---	2.094*
A_2B_2				---

*Significant at 0.05 level of significance

**Significant at 0.01 level of significance

A1: Stands for 4 MAT Teaching Model based Instructional Strategy

A2: Stands for Conventional Teaching Strategy

B1: Stands for Reproducing Learning Style

B2: Stands for Constructive Learning Style

From table 2, it is clear that t- ratio (3.329) for the difference in mean gain achievement scores in Economics of students having reproducing and constructive learning styles taught through 4 MAT teaching model based instructional strategy was found to be significantly different at 0.01 level of significance. The t-ratio (3.712) for the difference in mean gain achievement scores in Economics of students of experimental and control group having reproducing learning style was found to be significant at 0.01 level of significance. No significant difference (t-ratio, 1.692) was found in the mean gain achievement scores in Economics of students of the experimental group having reproducing learning style and control group having constructive learning style.

A significant difference (t-ratio, 8.076) in the mean gain achievement scores in Economics of students of the experimental group having constructive learning style and control group having reproducing learning style was found. On comparing experimental group students having constructive learning style and control group having reproducing learning style, a significant difference (t-ratio, 5.503) was found in the mean gain achievement scores in Economics. Further a significant difference (t-ratio, 2.094) was found at 0.05 level of significance in the mean gain achievement scores in Economics of students of the control group having reproducing and constructive learning style.

Discussion of Results

The results of the present study indicated that 4 MAT teaching model based instructional strategy was more effective for achievement in Economics as compared to conventional teaching strategy. The students taught through 4 MAT teaching model based instructional strategy outperformed the students who were taught through conventional mode of teaching. The results of the present study are consistent with the findings of Inel (2018) and Tuna & Aliustaoglu (2018) who concluded that the 4MAT teaching method was more effective than the existing teaching method in improving the academic achievement of the student. Seker & Ovez (2018) also found a significant gain in the student performance in Social Studies and Mathematics with the integration of 4MAT teaching model. Further, Demirkaya (2017) and Chittiwattanakorn & Sookkheo (2017) concluded that 4MAT teaching system improved the academic achievement significantly and found to be more successful than the traditional teaching. The findings by Tezcan & Guvenc (2017) showed that students taught with the 4MAT model fully attained the learning aims and got high achievement scores in Science. For Mathematics learning, Dikkartin-Ovez (2012) and Elci, Kilic & Alkan (2012) indicated that depending on the 4MAT teaching model based strategies led to

noticeable changes in the students' academic success. Aktas & Bilgin (2015) also concluded that the 4MAT model is more effective than traditional method in terms of enhancing achievement and motivation.

The results of the present study revealed that the achievement in Economics of students having reproducing and constructive learning style was significantly different. So, there exists no significant difference in the achievement in Economics of students having reproducing and constructive learning styles. The results of the present study are supported by the findings of Ergin & Sari (2012) who found a significant difference in achievement for the experimental group students who had different learning styles and 4MAT instruction method increased students' achievement significantly. Pratoomtong, Haemaprasith,

Boonprakob & Choochom (2012) concluded that achievement in science of students taught through science learning activities based on 4MAT system was higher than traditional teaching group of students but students who had different learning styles and learned through science learning activities based on 4MAT System had the same achievement.

The results of the present study showed a significant interaction effect of 4 MAT teaching model based instructional strategy and different learning styles on achievement of students in Economics. The findings of the present study are consistent with the findings of Elci, Kilic and Alkan (2012) who reported that 4 MAT model enhanced the academic achievement with respect to varied learning styles. Omeje (2014) also found that 4MAT teaching technique was superior to the conventional lecture method in enhancing the achievement of students with different learning styles in Biology.

Further, to determine the significance of the difference between means of various combination groups, t-ratios were computed and a significant difference was found in the achievement of Economics of experimental group students having reproducing and constructive learning styles; students of experimental and control group having reproducing learning style was found to be significantly different on achievement in Economics. However, no significant difference was found in the achievement of students of experimental group having reproducing learning style and control group having constructive learning style.

Significant difference was found in the achievement of students of the experimental group having constructive learning style and control group having reproducing learning style. Students of experimental group having constructive learning style and control group having reproducing learning style were found to significantly different on achievement. The control group students having reproducing and constructive learning style were also found to be significantly difference on achievement scores.

The 4MAT teaching model provides the students with an opportunity to perceive knowledge and experience in a field starting from concrete experiences to abstract conceptualization. The results revealed that 4MAT model based instructional strategy was effective in influencing the achievement of class +1 students in Economics. The 4MAT teaching model based instructional strategy and learning styles together had a significant interaction effect on the achievement of students in Economics. The findings have implications for the teachers of Economics that they may integrate 4MAT teaching model based instructions to improve the grades of students.

References

Aktas, I., & Bilgin, I. (2014). 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 and Technological Education, 32*, 1-21. Retrieved August 11, 2018 from http://www.tandfonline.com/doi/abs/10.1080/02635143.2014.968536?mobileUi=0&journalCode=crst20

Bhatia, G. & Sharma, M. (2017). CBSE Class 12 results: Economics and Maths have the highest failure rates. *The Hindustan Times, New Delhi, July 2, 2017.* Retrieved from https://www.hindustantimes.com/education/cbse-results-class-12-today-highest-failure-rate-in-economics-mathematics-

next/story-0DAf3dcYs0c3xemMPp7fAK.html

Bowers, P. S. (1987). *The Effect of the 4MAT System on Achievement and Attitudes in Science,* Ph.D. Theses, University of North Carolina at Chapel Hill. Retrieved August 16, 2018 from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.923.5023&rep=rep1&type=pdf

Brown, H. D. (2000). *Principles of language teaching and learning, (4th ed.).* White Plains, NY: Longman. Retrieved June 05, 2018 from https://download.atlantis-press.com/article/25902648.pdf

Cadenas, H, G. (1999). Revitalize your teaching – four key elements for success. *Contemporary Education,* 70 (2), 23-32. Retrieved on January 28, 2018, from Wilsonweb.comwebsite: http://vnweb.hwwilsoneb.com.proxy.lib.odu.edu/hww/jumpstart.jhtml?recid

Carol G. J., Richard H. J., Jenny N. L. & Ian M. M. (2000). An evaluation of collaborative problem-solving for learning economics. *Journal of Economics,* 31(1), 13-29. Published online March 25, 2010. Retrieved May 11, 2018 from https://www.tandfonline.com/doi/abs/10.1080/00220480009596758

Chittiwattanakorn, R., & Sookkheo, B. (2017). Using the 4MAT Model to Promote Learning Achievement and Connection Skills on Chemical Reaction of the 10th Grade Students. *RJES* 4(2). Retrieved December 22, 2018 from http://rjes.rsu.ac.th/Article/Article_Article_RJES_V4N2_Article_25-31.pdf

Demirkaya, H. (2017). Effect of the 4MAT system of instruction on the achievement of the students in Geography teaching. International. *Journal of Eurasia Social Sciences,* 8(29), 955-968. Retrieved September 11, 2018 from http://www.ijoess.com/Makaleler/1553286873_8-%20955

Dikkartın-Övez, F. T. (2012). The effect of the 4MAT model on student's algebra achievements and level of reaching attainments. *Int. J. Contemp. Math. Sciences,* 7(45), 2197-2205. Retrieved July 12, 2018 from http://www.m-hikari.com/ijcms/ijcms-2012/45-48-2012/ovezIJCMS45-48-2012.pdf

Elci, A.N., Kilic, D.S., & Alkan, H. (2012). 4 MAT Model's impact on the learning Styles, success and attitude towards Mathematics, *Journal of Educational and Instructional Studies in the world, 2*(3), 135 – 147. Retrieved September 24, 2018 from from www.wjeis.org/FileUpload/ds217232/File/wjeis_2012.3.complete.pdf

Ergin, S. & Sari, M. (2012). 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. *Energy Educ. Sci. Technol. Part B-Soc. Educ. Stud*., 4(2), 807-820. Retrieved October 21, 2018 from https://www.researchgate.net/publication/287466349

Ewumi, A. M. (2012). Gender and socio-economic status as correlates of students' academic achievement in senior secondary schools. *European Scientific Journal,* 8(4). Retrieved October 11, 2018 from https://doi.org/10.19044/esj.2012.v8n4p%p

Inel, Y. (2018). The effect of 4MAT method on the academic achievement of students in social studies education. *Review of International Geographical Education Online (RIGEO),* 8(3), 440-458. Retrieved January 14, 2019 from http://www.rigeo.org/vol8no3/Number3winter/RIGEO-V8-N3-2.pdf

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* New Jersey: Prentice-Hall Inc. Retrieved March 28, 2018 from https://www.researchgate.net/publication/235701029

MacKeracher, D. (2004). *Making sense of adult learning, (2nd ed.).* Canada: University of Toronto Press Incorporated. Retrieved October 17, 2018 from http://www.ipedr.com/vol5/no2/104-H10249.pdf

McCarthy, B. (1987). Using the 4MAT system to bring learning styles to schools.

Educational Leadership, 31-37. Retrieved from http://www.ascd.org/ ASCD/pdf/ journals/ed_lead/el_199010 mccarthy.pdf

McCarthy, B. (1990). Using the 4MAT system to bring learning styles to schools. *Association for supervision and curriculum development*. Retrieved May 10, 2017 http://www.ascd.org/ASCD/ pdf/journals/ed_lead/el_199010_mccarth y.pdf\

McCarthy, B., & McCarthy, D. (2006). *Teaching around the 4MAT cycle: Designing instruction for diverse learners with diverse learning styles.* Thousand Oaks, CA: Corwin Press.

Misra, K. S. (2012). *Manual Learning Style Inventory*. National Psychological Corporation, Agra.

Nancy & Bibbins, P. (1993). The effects of the 4MAT system of instruction on the attitudes and achievement of elementary children in music listening lessons. *An unpublished Ph.D. Thesis, Ball State University.* Retrieved October 13, 2018 from http://cardinalscholar.bsu.edu/ handle/handle/179460

Omeje, E. (2014). Effect of 4 MAT Technique on achievement, retention and multiple intelligences of students with different learning styles in Biology. *An unpublished Ph.D. thesis Faculty of Education, University of Nigeria.* Retrieved March 10, 2018 from http://www.unn.edu.ng/publications/files/ 17611_

Oxford Advanced Learner's Dictionary (2000). 6th Edition. U.K. Oxford University Press.

Pratoomtong, W., Haemaprasith, S., Boonprakob, M., & and Choochom, O. (2012). Effects of science learning activity management based on 4MAT system of the sixth grade students with different learning styles. *Journal of Education*, 35(1), 67-73. Retrieved June 19, 2018 from https://edu.kku.ac.th/journal/index.php/joe /article/viewFile/8/10

Seker , S. & Ovez, D. (2018). The Integration of the 4 MAT Teaching Model with the interdisciplinary structure. *EURASIA J Math Sci Tech Ed,* 14 (5), 1767-1790. Retrieved January 24, 2019 from https://www.ejmste.com/article/the-integration-of-the-4mat-teaching-model-with-the-interdisciplinary-structure-a-new-model-proposal-5385

Tezcan, G. & Güvenç, H. (2017). The effects of 4MAT teaching model and whole brain model on academic achievement in science. *Education and Science,* 42(192), 303-325. DOI: 10.15390/EB.2017.7085

Tuna, A. & Aliustaoglu, F. (2018). The influence of 4MAT Model on academic achievement and retention of learning in transformation geometry. *International Journal on New Trends in Education and Their Implications,* 9 (2), 16-32. Retrieved December 20, 2018 from https://www.researchgate.net/publication/ 326274079_

Wilkerson, R.M., & White, K.P. (1988). Effects of the 4MAT System of Instruction on Students' Achievement, Retention, and Attitudes. *The Elementary School Journal, 88*(4), 357 – 368. Retrieved July 10, 2018 from http://www.journals. uchicago.edu/doi/abs/ 10.1086/461544

Wichianmongkolkul, T. (2006). Effects of using the 4MAT System model in organizing THAI Language learning activities on attitudes towards Thai Literature and Learning Achievement of Lower Secondary School Students. *OJED,* 1(1), 34 – 39. Retrieved October 27, 2018 from www.edu.chula.ac.th/ojed/doc/V01/V01d/ v01d0004.pdf