University of Mohaghegh Ardabili 1978
RTBS Journal of A Review of Theorizing of Behavioral Sciences
License number from the Ministry of Culture and Islamic Guidance

Research Paper

The Role of John Zahorik's Constructivist Model in Enhancing the Mathematical Thinking Skills of Secondary School Students in Babil City

Ahmed Abdulnabi Jwaid[1]*, Ali Khaleghkhah[2]

1 Master's Student in Educational Management, Faculty of Humanities, University of Kashan, Iran.
Corresponding author: a416995@gmail.com
2 Department of Educational Sciences, Educational Sciences and Psychology, Mohaghegh Ardabili, Ardabil, Iran.

Received: 2024/01/25
Revised: 2024/05/20
Accepted: 2024/06/15

Use your device to scan and read the article online

Abstract
This study was conducted with the aim of examining the role of John Zahorik's constructivist model in enhancing the mathematical thinking skills of secondary school students in the city of Babil. This model, which emphasizes active learning and student participation, is considered a suitable alternative to traditional methods of teaching mathematics. The study was conducted using a quasi-experimental design with a post-test and control group. The sample consisted of 70 students who were randomly divided into experimental and control groups. The research tools included a mathematics academic performance test and a scale for assessing mathematical thinking skills. Data analysis using Multivariate Analysis of Covariance (MANCOVA) showed that John Zahorik's constructivist model significantly improved both academic performance and the enhancement of students' mathematical thinking skills. The results of this study suggest that teachers and educational policymakers should consider utilizing this model as an innovative and effective approach in mathematics education.

Keywords:
Mathematical Thinking, John Zahorik Model, Secondary School, Mathematics Education, Student, Babil City

Citation: Abdulnabi Jwaid, A., & Khaleghkhah, A. (2024). The Role of John Zahorik's Constructivist Model in Enhancing the Mathematical Thinking Skills of Secondary School Students in Babil City. *A Review of Theorizing of Behavioral Sciences, 1*(3), 1-14. doi: 10.22098/j9032.2025.16970.1041

Introduction

Mathematics is recognized as one of the most important tools for enhancing thinking and plays a significant role in the development of various cognitive skills. Learning mathematics lays the foundation for fostering logical and organized thinking in students, helping them to make effective decisions and solve problems when faced with various life challenges. In this regard, Mathematics is not merely about imparting knowledge; it also plays a key role in developing cognitive abilities and improving problem-solving skills, making it an essential tool for fostering logical thinking and making sound decisions (Boaler, 2015)

The John Zahorik educational model is designed with an emphasis on the active role of students in the learning process. In this approach, learners achieve a deeper understanding of concepts through their active participation in educational activities and practical experiences. This model creates an environment where students, through asking questions, group discussions, and solving various problems, are provided with opportunities for critical and creative thinking, and engage in constructing their individual knowledge (Majiwa, Njoroge, & Cheseto, 2020).

Based on the constructivist perspective, Zahorik model emphasizes that students actively construct their knowledge through interaction with the environment and learning experiences. In this framework, learning occurs through participation and exploratory and collaborative activities rather than a one-way transfer of information from teacher to student. As a result, the teacher's role as a facilitator and guide to the learning process becomes important, and the classroom space becomes an interactive and dynamic environment (Arpentieva, Retnawati, Akhmetova, Azman, & Kassymova, 2021).

Constructivism, as a theoretical framework, suggests that learners build knowledge through experiences and interactions rather than passively receiving information. This educational philosophy aligns with John Zahorik model, which emphasizes active student participation and encourages learners to develop their understanding of mathematical concepts through inquiry and exploration. Therefore, Zahorik model is a practical application of constructivist principles in the classroom, as it focuses on creating learning environments that facilitate student-centered activities and critical thinking (Shah, 2019).

John Zahorik constructivist model includes specific strategies and techniques designed to enhance mathematical thinking among students. One of these strategies is problem-based learning, which encourages students to engage with mathematical concepts by solving real-world problems (Arık & Yılmaz, 2020).

This approach allows students to apply theoretical knowledge in practical contexts, thereby deepening their understanding of mathematical principles. Furthermore, Zahorik model emphasizes collaborative learning environments where students work in groups to discuss and solve mathematical problems, thereby promoting critical thinking and peer learning (Steffe & Ulrich, 2014).

The application of the John Zahorik's constructivist model in classroom environments is based on several key principles that promote mathematical thinking skills among secondary school students. One of the main principles of this model is the emphasis on active participation, where students construct their understanding through problem-solving tasks and shared learning experiences (Rinke, Irish, & Berkowitz, 2018). In this approach, the focus shifts from external factors influencing learning to internal factors that affect it; meaning that in the face of educational situations, attention is directed toward what happens within the learner's mind, including prior knowledge and their abilities in recalling, understanding, applying, and analyzing (Mayer, 2005). John Zahorik model is one of the models that falls within the framework of constructivist theory and can be applied in various fields of knowledge, particularly in mathematical computations. Additionally, this model emphasizes the modification of concepts and information through their application, stating that understanding information is made possible by discovering subtle differences between new learning content and prior learning. This process enhances the learner's insight and facilitates the restructuring of their knowledge.

Zahorik teaching model, based on constructivist theory, progresses the teaching process in five consecutive steps. First, students review their previous learning to prepare for new concepts. Then, general information about the topic is provided, followed by students examining details and conducting an in-depth analysis of the concepts. The next stage is dedicated to the practical application of the material, during which learners engage in hands-on activities and practical projects. Finally, through reflection on what they have learned, students connect their knowledge to real life and generalize it (Mustafa & Fatma, 2013).

This model helps teachers design the learning process in a way that students actively participate in constructing new knowledge and are able to apply it in real-life situations.

Discussions about John Zahorik:

1. Definition of John Zahorik's Model (Definition of the Method): John Zahorik's model is a constructivist teaching method based on constructivist learning theories. This model is grounded in the idea that knowledge is actively constructed by the learner through experience, interaction, and reflection, rather than through the passive transfer of information from the teacher to the student. In this method, students gain a deeper understanding of subjects by participating in problem-solving activities, group discussions, and the discovery of concepts.

2. Features of the Method:

Active Participation of Students: Students act as knowledge constructors in the learning process and discover concepts through interaction with classmates and the learning environment.

Problem-Based Learning (PBL): Mathematical concepts are presented in the form of real-world, challenging problems, allowing students to apply theoretical knowledge in practical situations.

Emphasis on Critical Thinking and Problem Solving: This method encourages students to analyze, critique, and provide creative solutions.

Interactive Learning Environment: Classrooms are organized into collaborative groups, allowing students to reconstruct knowledge through discussion and cooperation.

Connection of Concepts to Real-Life: Mathematical concepts are linked to everyday issues to make learning more meaningful.

3. How This Method Can Replace Traditional Methods:

Addressing the Shortcomings of Traditional Methods: Traditional methods rely on rote memorization of formulas and passive learning, whereas Zahorik's model enables more sustainable learning by focusing on conceptual understanding and hands-on activities. In traditional methods, the teacher is the central figure, while in Zahorik's model, the student takes on the role of an active learner.

Changing the Role of the Teacher: The teacher transitions from being an information transmitter to a facilitator and guide of the learning process.

Using Diverse Tools: Resources such as interactive software, group projects, and laboratory activities replace the uniform traditional methods.

Teacher Training: Organizing workshops for teachers to familiarize them with the principles and techniques of Zahorik's model is essential.

4. Achievements of This Method:

Improved Conceptual Understanding of Mathematics: Students understand concepts through experience and interaction, rather than rote memorization.

Strengthening Cognitive Skills: Skills such as analysis, synthesis, evaluation, and problem-solving are enhanced in students.

Increased Engagement and Motivation: The dynamic and interactive learning environment increases students' interest and participation.

Preparation for Real-World Challenges: Students learn how to apply mathematics in solving real-life problems.

Reduced Math Anxiety: By removing the pressure of memorizing formulas, students gain more confidence when facing mathematics.

John Zahorik's model, by replacing traditional methods, not only enables deeper learning but also fosters essential 21st-century skills such as critical thinking, creativity, and collaboration in students. This method brings about a fundamental transformation, especially in the teaching of mathematics, which requires conceptual and practical understanding.

This research focuses on the role of John Zahorik's model in enhancing the mathematical thinking skills of high school students in the city of Babil. Rooted in constructivist learning theories, this model emphasizes the active participation of students and the construction of knowledge through experience and interaction. It challenges traditional teaching methods, which typically rely on memorization and passive learning, and instead suggests that students gain a deeper understanding of mathematical concepts by actively engaging in the learning process. This approach is particularly significant for high school students, as it aligns with their cognitive development stage, where abstract thinking becomes more prominent. The goal of teachers implementing Zahorik's model is to create an environment where students not only acquire mathematical knowledge but also develop critical thinking and problem-solving skills, which are essential for their academic and personal growth.

In today's educational systems, the use of traditional teaching methods, which primarily emphasize memorization and the transfer of information, is not sufficient to enhance students' critical and analytical thinking skills. This is especially true in mathematics, where the lack of interactive and active methods diminishes students' ability to apply mathematical concepts to real-life situations. One of the main concerns of this research is the students' weakness in the practical application of mathematics for analyzing everyday problems and making logical decisions. This challenge is particularly evident in schools where teaching still follows traditional, teacher-centered methods. In such settings, John Zahorik model, which emphasizes active learning and student participation, can provide an effective solution to improve mathematics education and enhance thinking skills.

The effectiveness of using John Zahorik's model in improving educational outcomes has been examined in several research studies. Some of these studies include the works of (Arık & Yılmaz, 2020; Shah, 2019; Tuama & Mohammed, 2019)

It can be said that most of these studies have reached a common conclusion, which is that John Zahorik's model effectively contributes to improving educational outcomes in various subjects and educational stages. This is achieved by enhancing the effective interaction between teachers and students and guiding educational activities in a way that allows students to develop their advanced thinking skills.

Despite these positive results and the abundant evidence regarding the effectiveness of this model in various academic fields, it is noteworthy that, according to the available information for the researcher, no study has specifically addressed the impact of Zahorik's model on teaching mathematics, particularly in relation to achieving cognitive education and enhancing mathematical thinking skills in secondary school students in Babil city. This gap in scientific research has motivated the researcher to design the current study, which aims to investigate the role of John Zahorik's model in enhancing the mathematical thinking skills of high school students in the city of Babil. This opens new horizons for understanding the applications of this model in a new and important specialized field.

Research methodology

The present research is applied in nature and follows a quasi-experimental post-test design with a control group. The sample consisted of 70 secondary school students from Ibn Idris School in Hilla, Babil Province, who were randomly divided into two groups: experimental and control. The research instruments included:

Mathematics Academic Test: With a Cronbach's alpha coefficient of 0.85, used to assess academic performance.

Mathematical Thinking Skills Scale: With a reliability coefficient of 0.82.

In this research, the main question is posed as follows:

Can John Zahorik's constructivist model significantly improve the academic performance and mathematical thinking skills of high school students?

For data analysis, Multivariate Analysis of Covariance (MANCOVA) was used, and the statistical assumptions included data normality (Kolmogorov-Smirnov test), homogeneity of variance-covariance (Box's M test), and absence of multicollinearity (Pearson correlation coefficient). This method was chosen for its ability to control for interaction variables (such as age, intelligence, parental literacy, and previous education) and to simultaneously examine the effect of the intervention on multiple dependent variables. The interaction variables were entered as covariates in the model to control their effects on the outcomes.

Table 1: Distribution of students in the research sample between the two research groups

Group	Section	Number of Students Before Removal	Number of Students Removed	Number of Students After Removal
Experimental	A	38	3	35
Control	B	40	5	35

Research Finding

For ensuring the equivalence of the experimental and control groups before the educational intervention, an independent t-test was conducted for the variables of age, intelligence, and parental literacy. The results presented in Table 1 indicate that there is no significant difference between the groups in the pre-tests ($p > 0.05$), suggesting homogeneity of the groups prior to the implementation of the Zahorik model.

Table 2: Results of the Pre-tests (Equivalence of Groups)

Variable	Experimental Group		Control Group		t	p
	Mean	SD	Mea n	SD		
Age	15.4	0.8	15.3	0.9	0.72	< 0/05
Intelligence (Raven's Test)	27.1	3.5	26.8	4.1	0.29	< 0/05
Parental Literacy	12.6	2.1	12.4	2.3	0.44	< 0/05

Table 3 shows the mean and standard deviation of academic performance scores and mathematical thinking skills for both the experimental and control groups. These descriptive statistics assist in comparing the results of the groups and provide a better interpretation of the statistical analyses.

Table 3: Descriptive Statistics of Variables

Group	Dependent Variable	Mean (M)	Standard Deviation (SD)	N
Experimental	Academic Performance	31.43	3.72	35
Control	Academic Performance	24.89	6.53	35
Experimental	Mathematical Thinking Skills	22.69	4.75	35
Control	Mathematical Thinking Skills	16.00	6.42	35

Multivariate Analysis of Covariance (MANCOVA) was used to analyze the data. This analysis allows the researcher to assess the effect of the Zahorik model on both dependent variables simultaneously, while controlling for the interaction variables.

Statistical Assumptions of MANCOVA

To ensure the validity of performing MANCOVA, the following were examined:

1. **Normality of Data Distribution**: Assessed using the Kolmogorov-Smirnov test.
2. **Homogeneity of Variance-Covariance**: Tested using Box's M test.
3. **Absence of Multicollinearity (VIF)**: Evaluated using Pearson's correlation coefficient.
4. **Linearity of Relationships**: Assessed by analyzing scatter plots.

Prior to performing the Multivariate Analysis of Covariance (MANCOVA), it is crucial to verify key statistical assumptions, such as normality, homogeneity of variance-covariance, and the absence of multicollinearity

.

Table 4: Assumption Tests for MANCOVA

Test	Test Statistic	Test Value	Significance Level (p)	Interpretation
Normality (Kolmogorov)	Age z	0.95	0.253	Data is normally distributed
Homogeneity of Variance-Covariance	Box's M	12.47	0.102	Homogeneity assumption is confirmed
Absence of Multicollinearity (VIF)	Maximum VIF	1.23		No multicollinearity present

Before conducting the MANCOVA analysis, the necessary statistical assumptions, including data normality, homogeneity of variance-covariance matrices, correlation between dependent variables, and the absence of multicollinearity, were carefully examined. The measurement tools included the mathematics academic test (comprising 32 multiple-choice questions) and the mathematical thinking skills scale, based on credible educational sources. In this context, the necessary statistical controls were implemented by including the correlated variables in the MANCOVA model, preventing potential confounding effects and ensuring the accuracy of the results.

To examine the effect of the John Zahorik model on academic performance and mathematical thinking skills, MANCOVA analysis was conducted after controlling for the interaction variables.

To examine the effect of the Zahorik model on academic performance and mathematical thinking skills, a MANCOVA analysis was conducted after controlling for interaction variables. Table 4 shows the results of statistical indices such as Wilks' Lambda and Pillai's Trace, indicating a significant difference between the experimental and control groups ($p < 0.001$)

Table 5: Results of the MANCOVA Test

Statistical Index	Value	F	Degrees of Freedom	Significance Level
Wilks' Lambda	0.72	16.8	(2, 67)	p < 0.001
Pillai's Trace	0.28	16.8	(2, 67)	p < 0.001
Hotelling's Trace	0.39	16.8	(2, 67)	p < 0.001
Roy's Largest Root	0.39	16.8	(2, 67)	p < 0.001

Important Statistical Indices

- Wilks' Lambda (Λ): 0.72, $p < 0.001$
- Pillai's Trace: 0.28, $p < 0.001$
- Hotelling's Trace: 0.39, $p < 0.001$

These results indicate a significant difference between the experimental and control groups in the combination of dependent variables.

To gain a more precise understanding of the impact of the Zahorik model on each of the dependent variables, univariate analyses were conducted. Table 5 presents the results of these analyses, showing that the Zahorik model had a significant effect on both dependent variables, with a larger effect size on academic performance (Partial Eta Squared = 0.26).

Table 6: Univariate Analyses (Post Hoc)

Dependent Variable	Group	Mean	Standard Deviation	F	p	Partial Eta Squared
Academic Performance	Experimental	31.43	3.72	24.16	p < 0.001	0.26
Academic Performance	Control	24.89	6.53			
Mathematical Thinking Skills	Experimental	22.69	4.75	18.54	p < 0.001	0.22
Mathematical Thinking Skills	Control	16.00	6.42			

To further examine the impact of the Zahorik model on each of the dependent variables, univariate tests were conducted:

1. Academic Performance in Mathematics:

- Mean score of the experimental group: 31.43 (±3.72)
- Mean score of the control group: 24.89 (±6.53)
- $F(1, 68) = 24.16$, $p < 0.001$

- Effect size (η^2): 0.26 (Large effect size)

2. Mathematical Thinking Skills:

- Mean score of the experimental group: 22.69 (±4.75)
- Mean score of the control group: 16.00 (±6.42)
- $F(1, 68) = 18.54$, $p < 0.001$
- Effect size (η^2): 0.22 (Large effect size)

In the section of academic performance in mathematics, the statistical indices of the MANCOVA analysis (such as Wilks' Lambda and Pillai's Trace) indicate a positive and significant effect of the Zahorik model. The obtained p-value is less than the significance level of 0.05, indicating that students in the experimental group performed better academically than those in the control group.

In the section of enhancing mathematical thinking skills, the statistical results also confirm that, after controlling for correlated variables, the constructivist model has a significant effect on improving students' mathematical thinking skills. The values of the statistical indices used in the multivariate analysis further reinforce this finding.

Table 7: Effect Size and Statistical Significance

Dependent Variable	Effect Size (Cohen's d)	Partial Eta Squared	Effect Size Interpretation
Academic Performance	1.14	0.26	Large
Mathematical Thinking Skills	1.04	0.22	Large

The effect size (Partial Eta Squared) for academic performance was 0.26 and for mathematical thinking skills, it was 0.22. Based on Cohen's 1988 criteria, these sizes are interpreted as large effects, indicating the significant impact of the John Zahorik model on improving academic performance and mathematical thinking skills. The results of the multivariate analysis of covariance (MANCOVA) showed that after controlling for correlated variables (age, intelligence, parental literacy, and prior academic performance in mathematics), a significant difference was observed between the experimental group (using the Zahorik model) and the control group (traditional method) in both indices of academic performance and enhancement of mathematical thinking skills.

The above results indicate that, for interpreting the large effect size of the teaching variable using the John Zahorik model on student progress in mathematics, there is a significant and favorable value for the experimental group. This demonstrates the effectiveness of John Zahorik constructivist teaching model in improving students' academic performance in mathematics.

Discussion & Conclusions

- The John Zahorik model has a positive impact on increasing the skills and learning of secondary school students in mathematics.
- This model also helps strengthen students' ability to perform basic mathematical thinking skills.

Effects of the Zahork Model on Academic Performance

John Zahorik constructivist model significantly improved students' academic performance in mathematics. The large effect size obtained indicates the considerable impact of this teaching method compared to traditional methods. The researcher attributes these results to several reasons, including:

- The John Zahorik model, which is derived from constructivist theory, provides the necessary conditions to help the learner acquire information on their own, rather than having this information delivered ready-made and without effort by the teacher. This approach ensures that the educational process is learner-centered.
- Teaching based on the John Zahorik model is more effective than the traditional method because it works to recall prior information and connect it with new information, which in turn stimulates interest and prompts the student to ask questions about the new lesson topic.
- One stage of this model involves reflecting on how newly acquired information can be applied both inside and outside the classroom. This helps the student think in a new and different way, by relating the course content to various aspects of daily life, which leads to greater acceptance of new methods by the student.
- The final stage of the John Zahorik model is thinking about the information, as this stage helps strengthen the learner's ability to discuss and exchange ideas with classmates or the teacher about the lesson topic. Additionally, the learner will be able to write a report on the same topic.

Impact on Mathematical Thinking Skills

The findings indicate that the Zahorik model has enhanced students' mathematical thinking skills. By emphasizing active and interactive learning, this model has helped students understand mathematical concepts more deeply and improve their analytical and critical thinking skills. The researcher attributes these results to several reasons, including:

- The lesson designed based on the John Zahorik model allows the learner to strengthen their mathematical thinking skills through the various stages of the model, which, in turn, helps the student effectively acquire these skills.

- The John Zahorik model emphasizes the conceptual connection between new learning and prior knowledge. Using their prior knowledge, the student learns new concepts and relates them to their personal understanding of the lesson topic.
- Teaching based on the John Zahorik model allows learners to develop their ability to assess their own performance and thinking methods. This evaluation is conducted by identifying strengths and weaknesses through discussion and by applying newly acquired knowledge in different contexts.
- Teaching based on the John Zahorik model has a significant impact on teaching scientific processes to students. This effectiveness is manifested through stimulating the student's attention and encouraging them to think by posing questions and writing reports, which ultimately leads to the development of the student's cognitive abilities and familiarizes them with enhancing mathematical thinking skills.

This study, by examining the role of the John Zahorik model in enhancing the mathematical thinking skills of secondary school students in Babil, demonstrated that this model can play a significant role in improving academic performance and developing students' cognitive skills. Unlike traditional teaching methods, which focus on one-way knowledge transmission and rote memorization, the Zahorik model emphasizes active learner participation, interaction with the educational environment, and engagement in the learning process. The findings of the study showed that students taught using this model performed better in academic tests and assessments of mathematical thinking skills compared to students who were taught using traditional methods.

The multivariate analysis of covariance (MANCOVA) revealed that John Zahorik constructivist teaching model significantly improved students' academic performance and enhanced their mathematical thinking skills. The use of this model, particularly in mathematics education, has led to more meaningful and deeper learning for students by creating an active and interactive learning environment.

The findings of the present study align with research such as(Ahmed, 2021; Arık & Yılmaz, 2020; Majiwa et al., 2020; Shah, 2019; Tuama & Mohammed, 2019), as these studies also reported significant and large effects of the Zahorik model on educational variables. However, the effect sizes reported in the current study for academic performance (0.26) and mathematical thinking skills (0.22) indicate a stronger impact compared to some previous studies, which may be attributed to the precise design of the intervention and the proper control of confounding variables. These findings emphasize that educational systems should move away from traditional teaching methods that rely on rote memorization and passive learning and shift toward active, student-centered teaching approaches. Due to its interactive and problem-based nature, the Zahorik model is one of the innovative and effective methods for teaching mathematics, which can facilitate meaningful learning for students.

Although this study showed that the John Zahorik model has positive short-term effects on academic performance and mathematical thinking skills, examining the long-term effects of this model requires future studies. It is suggested that in subsequent research, the impact of this model be investigated over longer time periods (such as one year or more) to assess the sustainability of these improvements.

Based on the findings of the research, several suggestions are made for improving mathematics teaching methods:

- Expanding the use of the Zahorik model in mathematics education: Since this model has demonstrated its effectiveness in improving students' mathematical thinking, it is suggested that more teachers and schools incorporate this approach into their curricula.
- Training and empowering teachers to implement this model: The successful implementation of the Zahorik model requires that teachers become familiar with the principles of this model and its teaching methods. Therefore, organizing training courses for teachers is essential.
- Developing educational content compatible with constructivist methods: It is essential that educational resources and tools, including textbooks, interactive software, and teaching aids, be designed in a way that aligns with constructivist methods.
- Conducting further research to examine the long-term effects of this model: Future studies could explore the long-term effects of the Zahorik model on students' academic progress and cognitive skills.
- Using the Zahorik model in other subjects: Given its effectiveness in mathematics, it is suggested that its efficacy be examined in other subjects, such as science and language.

Overall, the present study showed that John Zahorik constructivist model can be an effective and innovative method for teaching mathematics at the secondary level. This model, by engaging students in the learning process, helped them not only better understand mathematical concepts but also strengthen their critical thinking and problem-solving skills.

Therefore, changing teaching methods from traditional approaches to constructivist-based strategies can be an important step toward improving the quality of mathematics education and learning. Given the results of this study, it is recommended that educational authorities, teachers, and researchers seriously examine and implement this model in educational systems, as it could lead to a fundamental transformation in student learning and academic progress.

Resources

Ahmed, W. (2021). The effect of using John Zahorek's model in teaching social studies on cognitive achievement And developing the skills of divergent thinking among second-grade middle school students. *The Educational Journal, Faculty of Education, Sohag University, 91*(91), 4139–4179.

Arık, S., & Yılmaz, M. (2020). The effect of constructivist learning approach and active learning on environmental education: A meta-analysis study. *International Electronic Journal of Environmental Education, 10*(1), 44-84.

Arpentieva, M., Retnawati, H., Akhmetova, T., Azman, M., & Kassymova, G. (2021). *Constructivist approach in pedagogical science.* Paper presented at the Challenges of science.

Boaler, J. (2015). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*: John Wiley & Sons.

Majiwa, C., Njoroge, B., & Cheseto, N. (2020). Influence of constructivism instructional approach on students' achievement in Mathematics in secondary schools in Mandera Central Sub County, Kenya. *East African Journal of Education Studies, 2*(1), 115-128.

Mayer, R. E. (2005). *The Cambridge handbook of multimedia learning*: Cambridge university press.

Mustafa, E., & Fatma, E. N. (2013). Instructional technology as a tool in creating constructivist classrooms. *Procedia-Social and Behavioral Sciences, 93*, 1441-1445.

Rinke, C., Irish, T., & Berkowitz, A. (2018). Professional Growth Orientation and Collaboration: Mediating Roles in Science Teacher Professional Learning. *Science Educator, 26*(2), 81-89.

Shah, R. K. (2019). Effective Constructivist Teaching Learning in the Classroom. *Online Submission, 7*(4), 1-13.

Steffe, L. P., & Ulrich, C. (2014). Constructivist teaching experiment. In *Encyclopedia of mathematics education* (pp. 102-109): Springer.

Tuama, R., & Mohammed, A. (2019). The Effectiveness of the John Zahorik Model in Higher Thinking Skills among Grade the fourth Scientific Students in Biology *Journal of the College of Education for Women for .Human Sciences, 24*(2), 201-226