The effect of using Constructivist Approach in developing critical thinking skills of classification and identifying relationships in Mathematics among Secondary School students

[1]Albert Tobechukwu Nwamaradi (Ph.D.), [2]Edith Chinyere Onyeka (Ph.D.),

[1,2]Ph.D. (Science Education)
[1]Department of Science Education,
[1]Nnamdi Azikiwe University, Awka, Nigeria,

***Abstract*- Mathematics as a language is a mixture of Concepts and techniques developed to aid precise and logical thinking about the relationship between physical and abstract objects. The learning of Mathematics therefore involves learning of Mathematical concepts and learning of Mathematical techniques. Piaget had initially warned that efforts to introduce abstract concepts to students without the corresponding experience would not result in conceptual learning but would only lead to memorization (rote learning) or learning of techniques alone; although techniques cannot be mastered without rote memorization. The non-equivalent control group design was used for the study. A Traditional approach (Control treatment group) and a Constructivist approach (the Experimental treatment group), were used for the teaching of a Mathematics content (Statistics) and the students' critical thinking skills (CTS) of Classifying and Identifying relationships were tested using researcher constructed and validated instrument. The result showed that the mean post-test CTS of Classification for the Control treatment group was $\bar{x}= 28.96; SD = 6.34$ while the mean post-test CTS for the Experimental treatment group was $\bar{x}= 73.08; SD = 13.50$; and the mean post-test CTS of Identifying relationships for the Control treatment group was $\bar{x}= 57.54; SD = 24.68$ while the mean post-test CTS for the Experimental treatment group was $\bar{x}= 73.81; SD = 12.99$. An ANCOVA test of between-subjects effects showed a significant difference for both groups in each skill with p=0.000<0.05 between the mean post-test scores for the Control and Experimental groups but not for gender. This showed that the Constructivist approach to the learning of Mathematics was effective and results into conceptual learning of Mathematics content and development of CTSs of Classification and Identifying relationships for both male and females. The Constructivist approach to the learning of Mathematics is therefore recommended for the learning of Mathematics to ensure its application in daily life and logical living.**

***Keywords*: Increasing Critical thinking skills, reasoning, constructivist approach, constructivism in education, problem solving, developing critical thinking skills**

INTRODUCTION

The aims of Mathematics syllabus in secondary schools among others are the understanding of mathematical concepts and their application to everyday living and development of precise, logical, and abstract thinking. Obviously, these aims are peculiar to cognitive agents who are capable of conscious mental activities such as thinking, reasoning and remembering. Mathematics has been conceived as a language developed to aid precise and logical thinking about the relationship between physical and abstract objects. Can any approach to the teaching Mathematics lead students into developing those aims of Mathematics syllabus? In the past, the emphasis in classrooms has been on imparting information and content [1] Scholastic.com (2021). Now, the principal goal of education is to create men who are capable of doing new things, not simply of repeating what other generations have done. The second goal of education is to form minds which can be critical, can verify, and not accept everything they are offered [2] (Piaget in Cherry, 2019). With the shift of emphasis in the goal of education, comes the demand for teaching approaches that would result in the type of learning desired. Can the Constructivist approach to the teaching of Mathematics content create men who are capable of doing new things, not simply repeating what they have been taught, and form minds which can be critical, can verify, and not accept everything they are offered?

Meaning, nature, and learning of Mathematics

Mathematics as a body of knowledge, is a language developed to aid precise and logical thinking about the relationships between physical and abstract objects [3](Marshall Cavendish Limited, 1989). It is a mixture of Concepts and Techniques [4] (World Book Encyclopedia, 1996). While robots, and lower animals are capable of acquiring techniques; Concepts, however, are abilities that are peculiar to cognitive agents. [5] Moscovich (2006), strengthened this act of thinking about the relationship between objects when he argued that the human talent for pattern recognition is simply the understanding that there is a systematic relationship between the elements in nature. For him, when this relationship is sought out, found and expressed, that is the language of Mathematics. He summarized mathematics when he said that whenever there is relationship and pattern, there is mathematics. Concepts are ideas, People learn or understand them by thinking, discussing, reading, listening and/or writing about them

[6](Mathnasium, 2017). On the other hand, Skills or techniques are action, People do or master them, the same way they master musical skills or sports skills. They practice the actions and steps intentionally, correctly and frequently [6](Mathnasium, 2017).
It follows, then, that a necessary condition for a child to form a concept is his exposure to a variety of concrete situations in which the concept is embodied and the test of whether he has formed the concept is the ability to categorize correctly and reliably other situations as having or not having the concept [7](Gan, 1982). From the argument of [7] Gan (1982), it is evident that a child cannot think critically in an area until he or she develops concepts rather than techniques in the area. Their lack of understanding will limit their ability to apply math in a variety of problem solving situations. Mathematical skills, as opposed to concepts, are fundamentally techniques or methods of procedure by which a mathematical operation or problem can be worked out. The traditional way of teaching mathematics has always been to impart knowledge and to emphasize skills by telling or showing children how to obtain the correct answers and getting them to practice the skills as much as possible. We need to be aware, however, that while it is possible to drill children into learning mathematical rules and techniques, they may be doing so without an understanding of the mathematical principles which underlie them. No doubt, mathematical skills are important, but they should be learnt with mathematical understanding.

Critical Thinking skills of Classifying and Identifying Relationship

Critical thinking can be seen as having two components: 1) a set of information and belief generating and processing skills; and 2) the habit, based on intellectual commitment, of using those skills to guide behavior. It is thus contrasted with: 1) the mere acquisition and retention of information alone. 2) the mere possession of a set of skills because it involves a continual use of them, and 3) the mere use of those skills ("as an exercise") without acceptance of their results (Elder, September, 2007). People who think critically are keenly aware of the inherently flawed nature of human thinking when left unchecked. SkillsYou Need.com (2023) contend that Critical thinking is the ability to think clearly and rationally, understanding the logical connection between ideas. In essence, critical thinking requires one to use one's ability to reason. It is about being an active learner rather than a passive recipient of information.
In the past, the emphasis in classrooms has been on imparting information and content, however, there's been a shift toward teaching critical thinking, a skill that elevates thinking beyond memorization into the realm of analysis and logic [9](Scholastic Parents Staff, 2021). There are elements that experts agree are essential for critical thinking, such as being able to think independently, clearly and rationally. It involves the ability to reflect on an idea or problem, apply reason, and make logical connections between ideas [10] (Australian Christian College, 2023)
[11] Margot Note Consulting LLC (June 1, 2020) identified three types of Critical thinking skills namely: Analysis, Inference, and Evaluation. They located Identifying relationship and Classification within the critical thinking skill of "Analysis". For [12] Critical Thinking & Interpreting, (nd) classification and Identifying Relationship falls in the second and third levels of Blooms taxonomy of educational objectives in the cognitive domain respectively. Classification as a critical thinking skill plays an important role in critical thinking because it requires identification and sorting according to a rule, or set of rules, that kids must discover, understand, and apply [9] (Scholastic Parents Staff, 2021).

CONSTRUCTIVISM AND CONSTRUCTIVIST APPROACH

Teachers of Mathematics have often taking for granted that given the logical nature of their subject that once a student is taught Mathematics that the student is bound to develop the skills and habit of being critical, logical, and precise in his thinking. [13]Wejr (2010) summarized that "How you teach becomes what you teach", He further emphasized that "We cannot teach democracy by running our classes like a dictator. How something is taught becomes just as important as what is taught [14] (Werner and Bower, 1988).
Constructivism is a recent theory of learning and cognition which holds that people actively construct their own knowledge and that reality is determined by the experiences of the knower, rather than existing as an objective truth that is passively absolved, distinct from the individual [15](Johassen, in Elliott, Kratochwill, Cook, & Travers, 2000; [16] University at Buffalo, 2023).
In the statement of the objectives of mathematics at the secondary schools, there are objectives that focus at acquisition of information, and there are those focused on the application and use of concepts in mathematics. The goal of teaching is learning; the different forms of learning articulated by [17] TeachThought (2023) include Memorization, Acquiring facts or procedures, Understanding reality, and Making sense of the world.
But Piaget had initially warned that efforts to introduce abstract concepts to students without the corresponding experience would not result in conceptual learning but would only lead to memorization (rote learning). The point is to see that the more adequate our grasp of what we understand as "Knowledge", the more we can consciously, and morally play the educator
In mathematics education, the term "concept" repeatedly surfaces, often in contrast to the term "skill" or "techniques". Yet the teaching of mathematics as skills still predominates in our schools, particularly because advocates of conceptual learning often assume the value of concepts without explicitly defending it by defining precisely what they are. Until an adequate response to this question is given, the question of how to teach concepts will remain unanswered and the method of skill teaching will continue to dominate mathematics teaching [18] (Confrey, July, 1981).
In essence, critical thinking requires you to use your ability to reason. It is about being an active learner rather than a passive recipient of information.

Can Critical Thinking Ability Be Tested Or Developed?

Efforts to show that Critical thinking skills can be increased or developed by carefully planned intervention was established by Prat-Sala, (Sept. 17, 2020); [20]Lapuz and Fulgenico, (2020); and [21]Narmaditya, Wulandari, & Sakarji, (2018)
There are various well-validated tests that quantify critical thinking. Here's some examples:

The California Critical Thinking Assessment Test; The Watson Glaser Critical Thinking Appraisal; and The Cornell Critical Thinking Tests [10] (Australian Christian College, 2023).

Problem of the study

Given that Mathematics is composed of Concepts and Techniques, and given also, that the new emphasis in the goal of education is to create men who are capable of doing new things, not simply of repeating what other generations have done. Except the effect of various approaches to the teaching of Mathematics is scientifically established, It will remain unknown why mathematical concepts cannot be taught in the same way as mathematical techniques to attain these new goals. This research sets itself the problem of investigating the effect of using Constructivist Approach over the Traditional method of Mathematics teaching for the development of Critical thinking skills of Classifying and Identifying relationship in Mathematics among Secondary School Students.

Purpose of the study

The research will reveal the effect of using constructivist approach in teaching statistics in students' critical thinking skills of classifying, and Identifying relationships over the traditional approach of teaching statistics.

Research Questions

The following research questions were constructed to guide the study:

1. What are the mean achievements of students taught statistics using constructivist teaching approach (Experimental) and those taught using traditional approach (Control) in the Critical Thinking skill of classification?
2. What are the mean achievements of male and female students taught statistics using constructivist teaching approach and those taught using traditional approach in the Critical Thinking skill of classification?
3. What are the mean achievements of students taught statistics using constructivist teaching approach and those taught using traditional approach in the Critical Thinking skill of Identifying relationships?
4. What are the mean achievements of male and female students taught statistics using constructivist teaching approach and those taught using traditional approach in the Critical Thinking skill of Identifying relationships?

Research Hypotheses

The following research hypotheses were generated to guide the study:

1. There is no statistically significant difference in the mean Critical Thinking skill of classification at 0.05 level of significance between students taught statistics using Constructivist approach and those taught using traditional approach
2. Male and female students do not statistically differ significantly at 0.05 level of significance in the mean critical thinking skill of classification
3. There is no statistically significant difference in the mean Critical Thinking skill of Identifying relationship at 0.05 level of significance between students taught statistics using Constructivist approach and those taught using traditional approach
4. Male and female students do not statistically differ significantly at 0.05 level of significance in the mean critical thinking skill of Identifying relationships
5. There is no statistically significant interaction effect between constructivist teaching approach and gender of students at 0.05 level of significance.

Research Design:

The non-equivalent control group design; a type of quasi-experimental research experimental and control treatment groups was used. This research design is deemed appropriate as this experiment is basically to find out the effect of the use of Constructivist approach as an experimental treatment in developing critical thinking skills of mathematics among secondary school students using intact classes.

This design is also considered necessary as it was not possible to place students in groups by random assignment and the subjects in the different intact groups differ by number and gender. The Control group was included primarily to make it possible to measure the effect of extraneous factors upon the post test. [22] Kenny (1975) and [23] Jhangiani, R. S., Chiang, I. A., Cuttler, C., Leighton, D. C., & Metz, M, A, (nd)

commended the adequacy of this design where random assignment of experimental and Control treatments has not been applied or where the equivalence of the groups is not assured.

Treatments:

The control group was taught using the traditional method whereby knowledge is transmitted to students through lecture method, memorization and passive reception of knowledge while the Constructivist approach emphasized student active participation and engagement in the gathering of data and creation of knowledge, conceptual teaching and utilization of student experiences, students were given group projects and assignments. More activity based, using questioning, explaining, demonstration and collaboration techniques.

Instrumentation:

The instruments for the study comprised of

(a) Pre-test
(b) Post-test

Thirty six (36) Critical Thinking Skills achievement tests otherwise called Mathematics usage tests (MUT) consisting of fifteen (15) CTS tests for the skill of **Classification** and twenty one (21)CTS tests for the skill of **Identifying relationship** as validated by the valuators were used. Each is meant to test CT ability of students in Mathematics. The questions were spread over the four (4) content areas of Mathematics Curriculum in Statistics and two levels Blooms Taxonomy of educational objectives in the Cognitive domain as:

Table 1: Levels of Blooms Taxonomy Emphasized

Levels of Blooms Taxonomy	Content area				
	Organization of Data	Measures of typicality	Measures of dispersion	Positional measures	Total
Knowledge	7	2	4	2	15
Comprehension	8	5	4	4	21
Total	15	7	8	8	36

Reliability of Instrument

The reliability of the two Mathematics usage tests (MUT) of the sampled Critical thinking skills tests namely Classification & Identifying relationships were established using split half method. The correlation coefficients were determined as $r_{1/2}$ =.71 & .74 and the spearman-Brown correlation formula was used to determine the internal consistencies as; r = .84 and .90 respectively for Critical thinking skills of Classification and Identifying relationships

Validation of Instrument

Two (2) different Mathematics Usage tests (MUT) were constructed, each containing twenty five (25) questions. Five experts considered the questions for (1) the suitability of the items in testing for the particular CTS (2) the suitability of the language (3) the relevance of each item (4) other things deemed necessary in the wisdom of the experts and validated the tests

Items accepted or modified under the above mentioned conditions are those approved by at least three of the five experts. At the end 36 of the 50 questions were finally used as indicated in the table of classification. The Concurrent validity were further established using Pearson Correlation coefficient with r=0.81 and 0.83 for the skills of Classifying and Identifying relationship respectively.

Method of data Collection and Scoring of instruments

The tests were administered to the respondents by the researcher at intervals. The students responded to the items on the question papers in an answer sheet attached to each CTS tests. These test questions and their answer sheets were retrieved from the students as soon as each subject finished with answering the questions. After the first set, the students were allowed 30 minutes for recreation before commencing the last set.

Each CTS tests had a total score of 100%. Each of the CTS test had 5%. Total score of each student in any CTS test was calculated using the formula

$$T = \frac{(5n \times 100)}{5N} \qquad (1)$$

From "Equation 1" T is the total score by a student subject, n is the number of correct answers scored by each student on each CTS test, and N is the total number of questions in each CTS test.

Method of Data Analysis

The main threat to the internal validity of non-equivalent Control group design as in the present study is the possibility that group differences on the post test are due to pre-existing group differences arising from non-randomization rather than to a treatment effect.

The data collected was analyzed using SPSS with particular focus on Mean, standard deviation, and ANCOVA was used for the hypotheses tests. ANCOVA is chosen to partition out the variation due to the extraneous variables and to increase the precision of the experiment.

Results of Data Analysis

Research Question 1: What are the mean achievements of students taught statistics using constructivist teaching approach (Experimental) and those taught using traditional approach (Control) in the Critical Thinking skill of classification?

Table 2: Descriptives on Critical Thinking Skill of Classification & Identifying Relationship

Descriptive Statistics Dependent Variable: POST TEST SCORE OF SUBJECTS					Descriptive Statistics Dependent Variable: POST TEST SCORE OF SUBJECTS				
GROUPS IN THE EXPERIMENT	GENDER OF THE SUBJECTS	Mean	Std. Dev.	N	GROUPS IN THE EXPERIMENT	GENDER OF THE SUBJECTS	Mean	Std. Dev.	N
EXPERIMENTAL	MALE	73.333	14.975	12	EXPERIMENTAL	MALE	79.250	12.107	12
	FEMALE	72.857	12.667	14		FEMALE	69.143	12.234	14
	TOTAL	**73.077**	**13.496**	26		TOTAL	**73.808**	**12.989**	26
CONTROL	MALE	29.667	4.831	12	CONTROL	MALE	35.833	9.962	12
	FEMALE	28.400	7.453	15		FEMALE	31.333	9.904	15
	TOTAL	**28.963**	**6.340**	27		TOTAL	**33.333**	**10.000**	27

TOTAL	MALE	51.500	24.816	24	TOTAL	MALE	57.542	24.684	24
	FEMALE	49.862	24.767	29		FEMALE	49.586	22.096	29
	TOTAL	**50.604**	**24.563**	53		TOTAL	**53.189**	**23.418**	53
a. CRITICAL THINKING SKILL EMPHASIZED = **CLASSIFICATION**					CRITICAL THINKING SKILL EMPHASIZED = **IDENTIFYING RELATIONSHIP**					

Table 2 shows that the mean post achievements of students taught statistics using Constructivist approach (Experimental) is ($\bar{x}$= 73.08, S = 13.50) and those taught using the traditional approach (Control) is ($\bar{x}$= 28.96, SD = 6.34) in the critical thinking skill of classification.

Research Question 2: What are the mean achievements of students taught statistics using constructivist teaching approach and those taught using traditional approach in the Critical Thinking skill of Identifying relationships?

Table 2 shows that the mean achievements of students taught statistics using Constructivist approach (Experimental) is $\bar{x}$ = 73.81, SD = 12.99 and those taught using the traditional approach (Control) is $\bar{x}$ = 33.33, SD = 10 in the critical thinking skill of Identifying relationships.

Research Question 3: What are the mean achievements of male and female students taught statistics using constructivist teaching approach (Experimental) and those taught using traditional approach (Control) in the Critical Thinking skill of classification?

Table 2 shows that the mean achievements of students taught statistics using Constructivist approach (Experimental) is Male $\bar{x}$ = 73.33, SD = 14.97; Female: $\bar{x}$ = 72.86, SD = 12.67 and those taught using the traditional approach (Control) is Male $\bar{x}$ = 29.67, SD = 4.83; Female: $\bar{x}$ = 49.86, SD =24.77 in the critical thinking skill of Classification.

Research Question 4: What are the mean achievements of male and female students taught statistics using constructivist teaching approach and those taught using traditional approach in the Critical Thinking skill of Identifying relationships?

Table 2 shows that the mean achievements of students taught statistics using Constructivist approach (Experimental) is Male $\bar{x}$ =79.25, SD = 12.11; Female: $\bar{x}$ = 69.14, SD = 12. and those taught using the traditional approach (Control) is Male = 35.83, SD = 9.96; Female: 31.33, SD =9.90 in the critical thinking skill of Identifying relationships.

Research Hypotheses

Research Hypothesis 1: There is no statistically significant difference in the mean Critical Thinking skill of classification, at 0.05 level of significance between students taught statistics using Constructivist approach (Experimental), and those taught using traditional approach (Control).

Table 3: Analysis of Covariance on Tests of Between-Subjects Effects on the Critical Thinking Skills of Identifying Relationship and Classification

Tests of Between-Subjects Effects

Dependent Variable: POST TEST SCORE OF SUBJECTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23653.64[b]	4	5913.410	58.374	0.000
Intercept	4057.865	1	4057.855	40.057	0.000
PRESCORE	1160.490	1	1160.49	11.456	0.001
TREATMENT GROUPS	21209.22	1	21209.222	209.367	**0.000**
GENDER	340.719	1	340.72	3.363	**.073**
GROUPS * GENDER	206.336	1	206.34	2.037	**.160**
Error	4862.474	48	101.302		
Total	178455.00	53			
Corrected Total	28516.113	52			

a. CRITICAL THINKING SKIIL EMPHASIZED = **IDENTIFYING RELATIONSHIP**

b. R Squared = .829 (Adjusted R Squared = .815)

c. Computed using alpha = .05

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25939.225[b]	4	6484.81	57.27	0.000
Intercept	7327.053	1	7327.05	64.705	0.000
PRESCORE	151.193	1	151.19	1.335	.254
TREATMENT GROUPS	24278.837	1	24278.837	214.404	**0.000**
GENDER	2.141	1	2.141	.019	.891
GROUPS * GENDER	5.374	1	5.374	.047	**.828**
Error	5435.454	48	113.24		
Total	167094.000	53			
Corrected Total	31374.679	52			

a. CRITICAL THINKING SKIIL EMPHASIZED = **CLASSIFICATION**

b. R Squared = .827 (Adjusted R Squared = .812)

c. Computed using alpha = .05

Table 3 above shows that the mean score of the Experimental group ($\bar{x}= 73.08, S = 13.50$) differs significantly with the mean score of the Control group ($\bar{x}= 28.96, SD = 6.34$) in critical thinking skill of Classification with p=.000<.05. The experimental treatment was quite effective in developing critical thinking skill of classification among students. The table shows that more than 81% of the variability in the mean score on critical thinking skill of Identifying relationship is accounted for by the experimental treatment

Research Hypothesis 2: Male and female students do not statistically differ significantly at 0.05 level of significance in the mean critical thinking skill of classification

Table 3 shows that males with ($\bar{x}= 73.33; SD = 14.97$)and females with ($\bar{x}= 72.86; SD = 12.67$) do not differ in their mean score in Critical thinking skill of Classification with p=.891>.05

Research Hypothesis 3: There is no statistically significant difference in the mean Critical Thinking skill of Identifying relationship at 0.05 level of significance between students taught statistics using Constructivist approach and those taught using traditional approach

Table 3 above also shows that the mean score of the Experimental group ($\bar{x}= 73.81, S = 12.99$) differs significantly with the mean score of the Control group ($\bar{x}= 33.33, SD = 10$) in critical thinking skill of Classification with p=.000<.05. The table shows that more than 81% of the variability in the mean score on critical thinking skill of Identifying relationship is accounted for by the experimental treatment

Research Hypothesis 4: Male and female students do not statistically differ significantly at 0.05 level of significance in the mean critical thinking skill of Identifying relationships

Table 3 shows that males with ($\bar{x}= 79.25; SD = 12.11$) and females with ($\bar{x}= 69.14; SD = 12.23$) do not differ in their mean score in Critical thinking skill of Classification with p = .073 >.05

Research Hypothesis 5

There is no statistically significant interaction effect between constructivist teaching approach and gender of students at 0.05 level of significance for the critical thinking skill of Classification and Identifying relationships

From tables 3, the interaction effect between treatment and gender for the Critical Thinking skill of Classification is p = .828 > .05 shows that there is no significant interaction effect meaning that the treatment was equally effective for both male and female subjects. Similarly, the interaction effect between treatment and gender for the Critical thinking skill of Identifying relationships is p = .160 > .05 again showing that there is no significant interaction effect between treatment and gender for the Critical thinking skill of Identifying relationship respectively.

Cognitive abilities like thinking, reasoning and problem-solving may be considered to be some of the chief characteristics which distinguish human beings from other species including the higher animals; it enables the individual to make sense of the world [24]; [25]; [18]. (Reshma, nd; Sharma, nd; Confrey, July 1981).

Discussion:

The use of constructivist approach in teaching students statistics resulted in very high mean achievement of 73.08% and 73.81% for the Critical thinking skills of Classification and Identifying relationship respectively as in Table 2, while those taught the same content using the traditional teaching approach had a mean achievement of 29% and 33.3% for the same skills of Classification and Identifying relationship respectively. The differences in the mean achievements between the Experimental and Control groups for the Critical thinking Skills were tested for significance in table 3 using ANCOVA and the result showed a statistically significant difference in the Experimental and control group means for the two Critical thinking skills with a p-value of .000 and .000< .05 indicating that the differences in the mean achievements of experimental and Control groups is a real difference resulting from the superiority of the Constructivist Approach over the Traditional approach to the teaching of Statistics content of Secondary School Mathematics Curriculum for SSS3 students. The interaction effect showed a p-values of p =.828 and .160 respectively for Critical thinking skills of Classification and Identifying relationship respectively, revealing a non-significant interaction effect between the Experimental treatment and gender of subjects. Meaning that the experimental treatment was equally effective for both male and female subjects for the two skills. These findings synchronizes with the findings of show that Critical thinking skills can be increased or developed by carefully planned intervention established by Prat-Sala, (Sept. 17, 2020); Lapuz and Fulgenico, (2020); and Narmaditya, Wulandari, & Sakarji, (2018)

Conclusion

Mathematics is composed of “Concepts” and “Techniques; the term “concept” repeatedly surfaces, often in contrast to the term “Techniques”. Yet the teaching of mathematics as techniques still predominates in our schools; the question of how to teach concepts will remain unanswered and the method of teaching “Techniques” will continue to dominate mathematics teaching (Confrey, July, 1981). To learn (think), the teacher will have to engage the student using the student’s own experience

Today’s education system is seriously flawed – it focuses on teaching rather than learning thereby reconstructing the nature of Mathematics into content that can be acquired without thinking or experience. Critical thinking requires the teachers to engage students’ natural ability to reason, it is about being an active learner rather than a passive recipient of information. Constructivism is an approach that rigorously engages students to **question ideas and assumptions rather than accepting them at face value. The use of constructivist approach showed a significant positive effect on students’ achievement on the test of critical thinking skills**

Recommendation:

Critical thinking has been aptly defined by Elder, (Sept. 2007) as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing and/or evaluating information gathered from or generated by observation, experience, reflection, reasoning or communication as a guide to believe and action. It has been dubbed as a vital component of 21st century skills. This research has shown that teachers can more easily develop or increase this critical skills among Mathematics students, when teaching is done using constructivist approach. The following recommendations are therefore suggested:

1. Teachers should be made to focus on students' learning rather than teaching; by concentrating on students' own experiences as starting point for teaching. The Students should be led into planned experiences that contain the expected learning and be made to reflect upon those experiences.
2. Students should be made to think on their experiences by engaging the students natural ability to reason using constructivist approach; noting that Piaget had initially warned that efforts to introduce abstract concepts to students without the corresponding experience would not result in conceptual learning but would only lead to memorization (rote learning).
3. Teachers should rigorously engage students to question their ideas, and assumptions by being an active learner rather than being a passive recipient of information. Respecting children's experiences and or stages of mental development, that is the way to get them involved.
4. Teachers need to realize that based on the nature of Mathematics, that not all teaching approach will result in learning Mathematics; while mathematical facts, skills and techniques could be learnt by memorization and drill, Mathematical concepts can mainly be learnt by Constructivist approach. To be able to meet with the new goals of Mathematics education, It is always better and productive when a student is made to know Mathematical concepts and techniques; i.e. teachers should be made to know that mathematical concepts cannot be taught in the same way as mathematical facts, skills, and techniques to attain the new goals of Mathematics education.

REFERENCES:

[1] Scholastic.com (2021). Think About It: Critical Thinking. Retrieved 24th January 2023 from https://www.scholastic.com/parents/family-life/creativity-and-critical-thinking/learning-skills-for-kids/thin-about-it-critical-thinking.html#:~:text=Critical%20thinking:%20Categorize%20and%20classify,discover,%20understand,%20and%20apply .

[2] Cherry, K. (June 10, 2019). Developmental Psychology: Jean Piaget Quotes. Retrieved 24th January 2023 from https://www.verywellmind.com/jean-piaget-quotes-27951126

[3] Marshall, C. (1989). The New Illustrated Science and Invention Encyclopedia. Stuttman, H. S. Inc. Westport, Connecticut

[4] World Book Encyclopedia (1996). The World Book of Math Power 1: Dick Dell (ed. In Chief) Chicago. World Book Inc.

[5] Moscovich, I. (2006). The Big Book of Brain Games. Workman Publishing: New York

[6] Mathnasium.com (2017). How Math Concepts and Math Ski9lls Work Together and Why You Should Care. Retrieved 24th January 2023 from https://www.mathnasium.com/littleton

[7] Gan. K. S. (1982). Mathematical Concepts and Skills In Primary School Children. Retrieved 18th February 2023 from https://www.google.com/url?sa=t&source=web&rct=j&url=https://repository.nie.edu.sg/bitstream/10497/2764/1/TL-3-1-14.pdf&ved=2ahUKEwjBnNzh9I7xAhVBVhoKHQsnAxIQFjAMegQIIRAC&usg=AOvVaw1T3srIQxl4OsHo13k7GYtt

[8] Elder, L. (September, 2007) The Foundation for Critical Thinking: Defining Critical Thinking. Retrieved 24th January 2023 from https://www.criticalthinking.org/pages/definingcritical-thinking/766#:~:text=Critical%20thinking%20is%20the%20intellectually,guide%20to%20belief%20and%20action

[9] SCHOLASTIC PARENTS STAFF (2021). **Think About It: Critical Thinking.** Retrieved 2nd February 2023 from https://www.scholastic.com/parents/family-life/creativity-and-critical-thinking/learning-skills-for-kids/think-about-it-critical-thinking.html#:~:text=Classification%20plays%20an%20important%20role,discover,%20understand,%20and%20apply

[10]. Australian Christian College (10th November, 2019). Critical Thinking: an essential skill for every student. Retrieved 2nd February 2023 from https://www.acc.edu.au/blog/critical-thinking-essential-skill/

[11] Margot Note Consulting LLC(June 1, 2020). Three Levels of Critical Thinking. Retrieved 2nd February 2023 from https://www.margotnote.com/blog/2020/06/01/critical-thinking

[12] Critical Thinking & Interpreting (nd). **Why critical thinking is essential for interpreting practice?** Retrieved 2nd February 2023 from http://gpdmcriticalthinking.weebly.com/critical-thinking--interpreting.html

[13] Wejr, C. (May, 2010). How we Teach Is What We Teach- The Wejr Board. Retrieved 2nd February 2023 from http://chriswejr.com/2010/05/21/how-we-teach-is-what-we-teach

[14] Werner, D and Bower, B. (1988). *Helping Health Workers Learn*. USA; The Hesperian Foundation

[15] Elliott, S. N., Kratochwill, T. R., & Travers, J. F., (2000). Educational Psychology, Effective Teaching, Effective Learning (3rd Ed.). New York. McGraw Hill

[16] University at Buffalo, (2023). Constructivism. Retrieved 2nd February 2023 from https://www.buffalo.edu/catt/develop/theory/constructivism.html#:~:text=constructivist%20classroom%20activities-,What%20is%20constructivism%3F,%2Dexisting%20knowledge%20(schemas)
[17] TeachThought (2023). 20 Fundamentals: What Every Teacher Should Know about Learning?. Retrieved January 14, 2023 from http://www.teachthought.com/pedagogy/20-fundamentals-what-every-teacher-should-know-about-learning
[18] Confrey, J. (July, 1981). Concepts, Processes and Mathematics Instruction. Retrieved 2nd February 2023 from https://www.jstor.org/stable/40240741
[19] Prat-Sala, M. (September 17, 2020). Critical Thinking Performance Increases in Psychology Undergraduates Measured Using a Workplace-Recognized Test. Volume 49, Issue 2. Retrieved 2nd February 2023 from https://journals.sagepub.com/doi/full/10.1177/0098628320957981
[20] Lapuz, A. M. E; Fulgencio, M. N., (2020). Improving the Critical Thinking Skills of Secondary School Students Using Problem-Based Learning. Retrieved 2nd February 2023 from https://www.semanticscholar.org/paper/The-Effect-of-Problem-Based-Learning-on-Critical-%3A-Masek/4f472dc06281c45f765dc945599e92525b4c5679
[21] Narmaditya, B; Wulandari, D; Sakarji, S. R. (2018). Does Problem-Based Learning Improve Critical Thinking Skill? Retrieved 2nd February 2023 from https://www.semanticscholar.org/paper/The-Effect-of-Problem-Based-Learning-on-Critical-%3A-Masek/4f472dc06281c45f765dc945599e92525b4c5679
[22] Kenny, D. A. (1975). Quasi-Experimental Approach To Assessing Treatment Effects In the NonEquaivalent Control Group Design. NCJ Number 52180. Psychological Bulletin Volume: 82 Issue: 3. Pp. 345-362. 18 pages. Retrieved 18th March 2023 from https://www.ojp.gov/ncjrs/virtual-library/abstracts/quasi-experimental-approach-assessing-treatment-effects
[23] Jhangiani, R. S. Retrieved 18th March 2023 from A., Cuttler, C., Leighton, D. C., & Metz, M, A, (nd). Reseaerch Methods in Psychology. PressBooks. https://ecampusontario.pressbooks.pub/psychmethods3ecan/chapter/non-equivalent-control-group-designs/
[24].Reshma, S (nd). Thinking: Types, Development and Tools| Psychology. Retrieved 2nd February 2023 from https://www.psychologydiscussion.net/thinking/thinking-types-development-and-tools-psychology/2058
[25] Sharma, A (nd). Tools of Thinking: Brief Notes on 5 Tools of Thinking. Retrieved 4th February 2023 from https://www.psychologydiscussion.net/thinking/tools-of-thinking-brief-notes-on-5-tools-of-thinking/578