
Future teachers' mathematics cognitive failures and their learning styles

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ABSTRACT

This study investigated the disparities in the mathematics cognitive failures of future mathematics teachers based on learning style inclination. As a descriptive survey study, the sample included 480 future mathematics teachers from four universities in south-west Nigeria. Two research questions were involved and two instruments were used for the collection of quantitative data for the study: Learning Style Inventory (LSI, Cronbach alpha coefficient=0.74) and the Mathematics Cognitive Failures Questionnaire (MCFQ, Cronbach alpha coefficient=0.89). The collected data were analyzed using one-way Analysis of Variance (ANOVA), frequency, and percentage. Results showed that future mathematics teachers in varying degrees preferred the four learning styles of convergers, divergers, accommodators, and assimilators. In addition, there was a statistically significant influence of learning style on future teachers' mathematics cognitive failures. Thus, there were meaningful disparities in mathematics cognitive failures between accommodators and the other three types of future teachers: divergers, convergers, and assimilators. The disparity was in support of the accommodators. Succinctly, the accommodators pooled the greatest mathematics cognitive failures while the divergers recorded the least mathematics cognitive failures. In line with these study findings, it is advised that strategies that could reduce future teachers' mathematics cognitive failures and close the gaps created by learning styles should be enacted to promote their success in mathematics learning.

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1. INTRODUCTION

Ever since mathematics has come to stay in the school curriculum, curiosity has developed in the assessment of students' errors in mathematics (Kyaruzi, Strijbos, Ufer, & Brown, 2019; Larrain & Kaiser, 2019; Pankow et al., 2016; Rakoczy et al., 2019; Saralar, Ainsworth, & Wake, 2018). This interest is due to the seemingly unending poor performance of students in mathematics, which perhaps has been ascribed to errors committed when solving mathematics problems. In broad, Olivier (1989) distinguished among errors, slips and misconceptions. To him errors are incorrect solutions or mistakes due to planning and are systematic because they are applied constantly in the same circumstance. Slips are defined as incorrect solutions or

mistakes accustomed by processing although they are easily detected and corrected they are not systematic but are occasionally and sloppily made by both specialists and non-specialists. Misconceptions are mistaken beliefs or false impressions that underlie theoretical constructions that produce errors (Sisman & Aksu, 2016). In essence, errors are pointers to the presence of misconceptions (Moru, Qhobela, Poka, & Nchejane, 2014) and are by-products of human-disturbed information processing or cognitive functioning (Parker, Reason, Manstead, & Stradling, 1995) in which personal variances in mental capability can produce diverse categories and degree of incorrect solutions that people make in the same situation (Allahyari et al., 2008).

In relation to mathematics, Legutko (2008) classified errors into mathematical and didactical. An individual who takes a false mathematical sentence as true commits mathematical errors. Didactic error connotes a condition in which a teacher behaviour is inconsistent with the instructive, procedural and corporate logic rules. Mathematical errors involve making mistakes in the definition of mathematical concepts and making erroneous applications of the definitions, generalizing once noticing a few specific cases and improper adoption of mathematical terminologies (Legutko, 2008). Didactical errors involve the wrong assortment of instances used in concept creation and illogical structure of teaching such as teaching abstract concepts, which is of higher-order before concrete concept, which is of lower order (Legutko, 2008). There are three types of mathematical errors and they are arbitrary, structural and executive (Orton, 1983). Executive errors are committed when an individual fails to implement operations, although the frameworks connected are clear. Structural errors occur when an individual fails to understand the associations convoluted in the problem or fails to comprehend the underlying principle crucial to the solution. Arbitrary errors are committed when an individual who acts indiscriminately fails to comprehend the restraints convoluted in the given problem.

It is important to note that errors due to cognition play a role in students' poor performance in mathematics. More often than not students in mathematics classes may be confronted with a daunting challenge of perceptual failures, or failures of memory, or actions that are misdirected in an attempt to solve mathematical problems. Thus, there is a common symptom in, which the intention does not match the actual practice in the mathematics classroom and students are left bewildered not knowing what steps to take to arrive at a candid solution to the problem. This situation is quite different from a lack of ability and in the actual sense the ability to perform such mathematical tasks is present but sometimes other factors relating to errors of cognition may set in to bring about a flop in seemingly laughable simple tasks, which students would naturally solve without mistakes. Such errors of cognition may include episodes of absent-mindedness, forgetfulness, spacing out, decreased consciousness level, daydreaming, action slips, deviated attention and lapses of memory, which interfere with solving mathematical tasks.

These errors of cognition have been termed mathematics cognitive failures, which refer to individual differences in proneness to errors in routine mathematical activity and problem-solving (Awofala & Odogwu, 2017). Mathematics cognitive failure is perceptual, attentional, memory, and action-related lapses of awareness in relation to the study of mathematics. Mathematics cognitive failures refer to powerlessness in magnificently carrying out mathematical tasks that a person might naturally be able to execute on a regular basis (Awofala & Odogwu, 2017). Mathematics cognitive failure is a derivative of cognitive failure first mooted by Broadbent et al (1982). Mathematics cognitive failures cover several kinds of mathematics implementation lapses namely lapses in attention (i.e., flops in discernment), lapses in memory (i.e., let-downs connected to information recovery), and lapses in mechanical function (i.e., the enactment of accidental actions, or action slips). Mathematics cognitive

failures are described as cognitive-based errors on simple mathematical tasks and problem-solving that a person should normally be able to execute without mistakes.

In the lapse in mathematical awareness being discussed, it is important to note its relation with affective constituents of clinical problems in mathematics schoolroom, which most often are concerned with attention, memory, and control of thought or action syndromes. One affective disorder in mathematics that has been related to mathematics cognitive failure is mathematics anxiety. Awofala and Odogwu (2017) found that mathematics anxiety is a significant factor in mathematics cognitive failures of preservice teachers with the preservice teachers showing a high incidence of lapses in mathematics awareness. More so, there was a positive momentous association between mathematics cognitive failures and anxiety towards mathematics among preservice mathematics teachers. As can be inferred from Awofala and Odogwu (2017) study preservice teachers with a high rate of mathematics cognitive failure are most likely to report a high incidence of a more debilitating affective symptom of mathematics anxiety.

Presently, only one measuring tool exists in probing a person susceptible to committing a mathematics cognitive failure: the Mathematics Cognitive Failures Questionnaire (Awofala & Odogwu, 2017). This measure was established to evaluate everyday failures in perception, memory, and motor function associated with mathematics and problem-solving. As seen by Awofala and Odogwu (2017) mathematics cognitive failure is a multi-factorial construct consisting of lack of concentration, motor function, distractibility, and memory. MCFQ scores seem to predict standard measures of mathematics performance and show a relationship with self-reported mathematics anxiety (Awofala & Odogwu, 2017). It is contended that the MCFQ measures vulnerability to mathematics anxiety (Awofala & Odogwu, 2017). When exposed to high stake mathematics testing situations, individuals with high MCFQ scores may develop mathematics anxiety symptoms that may have a damaging effect on their mathematics performance because they are less efficacious in using active coping strategies (Awofala & Odogwu, 2017). The sources of mathematics cognitive failure can be categorized into four broad groups (Awofala & Odogwu, 2017): lack of concentration, memory dysfunction, motor-function lapses, and distractibility. The lack of concentration can be the outcome of low listening and low thinking abilities in mathematics. Memory dysfunction is initiated by forgetfulness and slothfulness in mathematical thought. Motor function lapses could be a result of the inability to make up one's mind in mathematics and the performance of unintended action and distractibility is triggered by daydreaming and distraction in mathematics.

Currently only one study has been conceived with mathematics cognitive failure. Awofala and Odogwu (2017) explored preservice teachers' mathematics cognitive failures in connection to mathematics anxiety in the presence of undergraduate performance in calculus. The results showed that mathematics cognitive failure has four interpretable dimensions, which include distractibility, motor function, lack of concentration, and memory. In addition, mathematics anxiety influenced pre-service teachers' mathematics cognitive failures. The relations between mathematics cognitive failures and learning styles have been rarely researched. In the meantime, this paucity of research in the extant literature has led to this investigation.

According to Kolb (1984), learning is the progression in which knowledge is created via the renovation of practice. Knowledge is the fall-out from the synthesis of acquisitive and renovating practice. This practice is umpired on four dimensions: (i) sentimental (emotion, intuiting), (ii) figurative (reasoning, rational skills), (iii) developmental (doing), and (iv) perceptual (skills of surveillance). The Experiential Learning Theory (ELT) model reveals two

dialectically connected types of acquisitive practice-Concrete Experience (CE) (feeling) and Abstract Conceptualization (AC) (abstractness, thinking)-and two dialectically connected types of renovating practice-Reflective Observation (RO) (reflection, watching) and Active Experimentation (AE) (action, doing). Hypothesizing an experiential model of erudition, Kolb visualizes the four facets as forming a cone base, as a person matures with the learning style becoming multifaceted (Koob & Funk, 2002). Learning style shows personal disparities in learning in accordance to students' inclination for hiring diverse segments of the erudition rotation. According to ELT learning style is defined as a flexible attribute, rising from a person's favoured doggedness of the twofold interactions of feeling/abstracting and performing/replicating (Kolb & Kolb, 2005a, 2005b).

Kolb (1984) made known four learning styles connected with diverse methodologies to erudition—Accommodating, Assimilating, Diverging, and Converging with the features and merits of the learning styles kinds enunciated (Kolb, 1984, 1985; Baker, Dixon, & Kolb, 1985). A diverger has the concrete experience and reflective observation as governing learning capabilities. Learners who are divergers see physical conditions from diverse viewpoints. Divergers are at their best in generating and synthesizing ideas through brainstorming activities. Divergers are information seekers and are lovers of culture. They are sociable and make friends easily, incline to be creative and passionate, and are arts inclined (Hawk & Shah, 2007). In schooling, divergers favour working in teams, are open-minded and like to get customised reactions (Kolb & Kolb, 2005a, 2005b).

An assimilator possesses abstract conceptualisation and reflective observation as overriding learning capabilities. Assimilators are good at synthesising varied information and placing it into a succinct and rational system. They are not people oriented but are more receptive to notions and non-figurative concepts. Normally, assimilators are theory thinkers and value abstract conceptualisation than practical value. They make a good career in science related disciplines. In schooling, assimilators favour analytical thinking in reading and lecturing (Kolb & Kolb, 2005a, 2005b). Learners with assimilating learning styles possess the capacities to synthesize conceptual theories and favour inductive reasoning for dealing with abstract ideas (Hawk & Shah, 2007).

A converger possesses active experimentation and abstract conceptualisation as foremost learning aptitudes. Convergers like to put ideas and theories into practical use and application. They are problem solvers, decision makers and technical about tasks and problems. They are less concerned with social and relational issues. Convergers take to careers in technology. In schooling, convergers support experimentation with novel ideas and they like to engage in simulations, and are practical oriented with laboratory activities (Kolb & Kolb, 2005a, 2005b). Convergers have a robust concrete alignment, are commonly inferential in their thought, and are inclined to be dispassionate (Hawk & Shah, 2007).

An accommodator has concrete experience and active experimentation as prevailing learning facilities. They like to engage in hands-on activities and are plan executors who love novel challenges. They are less logical in analysis but always act on 'gut' feelings. They rely on information from other people rather than engaging their technical scrutiny. Accommodators work well in action-dominated professions like marketing or sales. In schooling, accommodators are sociable in their interaction with others in getting assignment done; they are goal initiators and like fieldwork; and they like to put to test diverse methods to finalising a project (Kolb & Kolb, 2005a, 2005b). In general, accommodators like to take risks and possess the skill of solving problems instinctively (Hawk & Shah, 2007).

Knisley (2001) gave a mathematical interpretation of Kolb's learning styles in which the divergers (concrete, reflexive) are named allegorizers, accommodators (concrete, active) as integrators, assimilators (abstract, reflective) as analyzers, and convergers (abstract, active) as synthesizers. Allegorizers are students who regard novel notions as reformulations of previously encountered notions. They tackle problems through the application of previously acquired methods in an ad-hoc manner. Integrators are students who depend largely on the comparisons of novel notions to previous notions. They tackle problems by applying their "common sense" insights—i.e., by comparing the problem to problems they can solve (Knisley, 2001). Analyzers are those students that crave for rational elucidations and algorithms. They tackle problems with a rational, step-by-step progression that starts with the prior assumptions and ends with the solution (Knisley, 2001). Synthesizers are students who view concepts as instruments for building novel notions and methods. They tackle problems by constructing personal strategies and novel allegories.

The present study was undertaken to investigate the future mathematics teachers' learning styles and to find out their mathematics cognitive failures based on learning styles. This study is significant in that this is the first time the relation between Kolb's learning styles and mathematics cognitive failures would be investigated. Specifically, this study sought to find answers to the following research questions:

Research Question 1. What is the dominant Kolb's learning styles of future mathematics teachers?

Research Question 2. What is the influence of Kolb's learning style on future teachers' mathematics cognitive failures?

2. METHOD

In this study, a numerical exploration scheme within the outline of the descriptive survey design was espoused. The respondents consisted of 480 future mathematics teachers (270 males and 210 females) from four Universities in South-West Nigeria. They fell within the age range of 16 to 28 years with a mean age of 21.8 years. The respondents could similarly be characterised as 220 (45.83%) in the age range below 20 years and 260 (54.17%) in the age range 20-34 years. 130 (27.08%) were freshmen [60 (46.15%) males, 70 (53.85%) females, $M_{age} = 17.2$ years, $SD = 1.3$, age group: 16-23 years], 120 (25%) were sophomores [80 (66.67%) males, 40 (33.33%) females, $M_{age} = 18.3$ years, $SD = 1.6$, age group: 17-24 years], 110 (22.92%) were juniors [60 (54.55%) males, 50 (45.45%) females, $M_{age} = 19.3$ years, $SD = 1.7$, age group: 19-27 years], and 120 (25%) were in seniors [70 (58.33%) males, 50 (41.67%) females, $M_{age} = 20.3$ years, $SD = 1.9$, age group: 20-28 years].

Two instruments tagged Mathematics Cognitive Failures Questionnaire (MCFQ) adopted from Awofala and Odogwu (2017) and Learning Style Inventory (LSI) adopted from Kolb (1985) were positioned for the collection of primary data connecting to mathematics cognitive failures and learning styles correspondingly. The MCFQ consisted of 25 items anchored on a 5-point modified Likert scale ranging from: Very often -4, Quite often -3, Occasionally -2, Very rarely -1, to Never -0. According to Awofala and Odogwu (2017), the MCFQ had a Cronbach alpha reliability coefficient of 0.94. Factor analysis revealed four interpretable factors for the MCFQ. These are Lack of concentration – 3 items (factor loading ranging from 0.637 to 0.698), Motor function – 4 items (factor loading ranging from 0.615 to 0.863), Memory – 9 items (factor loading ranging from 0.642 to 0.819), and Distractibility – 9 items (factor loading ranging from 0.707 to 0.846) (Awofala & Odogwu, 2017). The Cronbach alpha reliability

coefficients were lack of concentration ($\alpha = .860$), motor function ($\alpha = .881$), memory ($\alpha = .939$) and distractibility ($\alpha = .922$) (Awofala & Odogwu, 2017). In the present study, the reliability coefficient obtained for the mathematics cognitive failures using the Cronbach alpha is 0.89 and this is considered highly reliable.

The LSI is made up of four learning modes: concrete experience (CE) refers to as feeling, reflective observation (RO) refers to as watching, abstract conceptualisation (AC) refers to as thinking, and active experimentation (AE) refers to as doing. Kolb (1985) maintained that pairs of the learning modes may be epitomised along two continuum of active-reflective known as doing-watching and concrete-abstract known as feeling-thinking. A person is a christened accommodator (AC) if he/she is more active than reflective and more concrete than abstract. A person is termed converger (CO) if he/she is more active than reflective and more abstract than concrete. A person is a christened assimilator (AS) if he/she is more reflective than active and more abstract than concrete whereas a person is termed diverger (DI) if he/she is more reflective than active and more concrete than abstract. These learning styles are epitomised in the four quadrants of the plane. The LSI consisted of 12 incomplete statements with four probable completion phrases in which the participants are expected to rank the completion phrases numbered from 1 to 4 with '1' stood for the least like the way learned and '4' stood for the most like the way learned. The four learning modes are used in depicting a person learning style by getting the grand score for each of the four learning modes over the 12 items and subsequently use this to categorise the person into one of the learning styles. It should be noted that the AE-RO is on the horizontal axis while the AC-CE is on the vertical axis with positive scores from AE-RO showing that learning is active and negative scores indicating that learning is reflective. Likewise, positive scores from AC-CE depict that learning is abstract whereas negative scores show that learning is concrete. The coordinates AE-RO and AC-CE are plotted on the plane to get the person's learning style so that the point where the coordinates meet represents the learning style of the person. In this study, the reliability coefficients of the LSI were calculated using the Cronbach alpha and the following reliability coefficients were obtained: CE: 0.80, AC: 0.76, AE: 0.78, RO: 0.75 and 0.74 for the entire LSI. Both face and content validity of the MCFQ and LSI were ensured by given the questionnaires to three mathematics educators in a Univeristy in South-West, Nigeria. They recommended that the two questionnaires were good for the study before their administration on the target sample.

The authors in the company of twelve research supporters oversaw the administration of the MCFQ and LSI to the entire sample and in commonly arranged classes in the four Universities. The collected data were condensed and examined using percentage, mean, standard deviation and analysis of variance (ANOVA) at $\alpha = 0.05$ level of significance.

3. RESULTS AND DISCUSSION

Research Question One: What is the dominant Kolb's learning styles of future mathematics teachers?

Table 1 revealed the frequency and percentage for future mathematics teachers' learning style penchant. In this table, the respondents preferred all the four types of learning styles in different frequencies and percentages. The accommodators pooled the highest frequency and percentage 144 (30%) of the future mathematics teachers cohorts and were ranked 1st. This was followed by the divergers who pooled a frequency and a percentage of 122 (25.42%) and were ranked 2nd. The assimilators had a frequency and percentage of 114 (23.75%) of the future mathematics

teachers and were ranked 3rd. The convergers recorded the lowest frequency and percentage of 100 (20.83%) of the future mathematics teachers in the study and were ranked 4th.

Table 1. Frequency and percentage for the future teachers' learning styles

	n	%	rank
Divergers	122	25.42	2 nd
Assimilators	114	23.75	3 rd
Convergers	100	20.83	4 th
Accommodators	144	30.00	1 st
Total	480	100	

Research Question Two: What is the influence of Kolb's learning style on future teachers' mathematics cognitive failures?

In line with Table 2, the divergers recorded the least mean score of mathematics cognitive failures (Mean=53.93, SD=18.92). Contrastingly, the accommodators pooled the greatest mean score of mathematics cognitive failures (Mean=64.04, SD=17.02). As detailed in Table 2, there were disparities in mean scores of mathematics cognitive failures regarding the four learning styles. These differences were confirmed using one-way Analysis of Variance (ANOVA). As shown in Table 3. The ANOVA revealed that there was a numerically momentous influence of learning style on future teachers' mathematics cognitive failures [$F_{(3,479)} = 7.782, p < .001$]. To know the direction of significance among the four learning styles regarding mathematics cognitive failures, the Bonferroni multi-comparison test was implemented. The test showed that there was a numerically momentous difference in mathematics cognitive failures between the accommodator and the other three types of future teachers, divergers, assimilators and convergers in favour of the accommodators. Whereas, there were no numerically momentous disparities in mathematics cognitive failures among convergers, divergers, and assimilators. This study revealed that the divergers pooled the lowest mathematics cognitive failures than the three other types of future mathematics teachers classified based on learning style.

Table 2. The frequency, mean and standard deviation for the future teachers' mathematics cognitive failures by learning styles

	N	Mean	St.D
Divergers	122	53.93	18.92
Assimilators	114	57.76	17.49
Convergers	100	55.45	20.77
Accommodators	144	64.06	17.02
Total	480	58.20	18.84

Table 3. One-way ANOVA results for the future teachers' mathematics cognitive failures by learning styles

	Sum of Squares	df	Mean Squares	F	p
Between Groups	7946.930	3	2648.977	7.782	.000*
Within Groups	162019.268	476	340.377		
Total	169966.198	479			

*p<.001

The result of this study showed that future mathematics teachers preferred all the four learning styles in varying percentages. The accommodators ranked first. The divergers ranked second. The assimilators ranked third while the convergers ranked fourth. This result confirmed

the previous findings in which pre-service teachers preferred the four learning styles in varying percentages (Akinyode & Khan, 2016; Ata & Cevik, 2019; Orhun, 2012, 2013; Peker, 2005, 2009; Peker & Mirasyedioglu, 2008). The disparity in the distribution of the learning styles is normal considering the fact that no two future mathematics teachers are totally the same as there bound to be individual differences between them. In Peker's (2009) study, it was established that the convergers ranked first, the assimilators ranked second, the accommodators ranked third while the divergers ranked fourth. In Orhun's (2007) study, no students preferred the accommodator learners while the convergers recorded the highest percentage among the mathematics students in the university. In a study conducted by Orhun (2012), it was made open that the convergers ranked first, assimilators ranked second, divergers ranked third while the accommodators ranked fourth.

This study investigated the disparities in the future teachers' mathematics cognitive failures based on learning styles. It was established that there was a statistically significant influence of learning style on future teachers' mathematics cognitive failures. In addition, the accommodators recorded the greatest level of mathematics cognitive failures, trailed by the assimilators. The convergers came third with the divergers recording the least mathematics cognitive failures. Unfortunately, there are no precursor findings that one can fall back on in explaining the finding of this study. However, having low mathematics cognitive failures is good for the enhancement of students' performance in mathematics. Based on this, the divergers may be more successful in mathematics learning than the other learning styles. This is because divergers are resourceful and passionate about mathematics activities as they recognize mathematical information physically and process it meditatively. They regard novel ideas as reformulations of previously encountered ideas, thereby making their learning of mathematics more permanent since they now have schema on which to build newly found ideas. This, however, contradicted Peker (2005) submission that the convergers were more efficient than the other learning styles since they recorded the lowest level of mathematics teaching anxiety. Having high mathematics cognitive failures should be discouraged among future teachers, as this may prevent them from understanding mathematics. This is because cognitive failures may interfere with their understanding of mathematics. This interference may inhibit their performance in mathematics, making the future teacher record low performance in mathematics. This is supported by the finding of some studies that reported cognitive failures to contribute to poor performance in problem-solving or understanding (Baidoo, 2019; Beilock & DeCaro, 2007; Rofiki et al., 2017; Rofiki & Santia, 2018; Rong & Choi, 2019). Therefore, mathematics cognitive failures may be considered an essential inhibitor of mathematics achievement in future teachers. The learning style that leads to a drop in future teachers' mathematics cognitive failures may be regarded as suitable for learning. As indicated in this study, the divergers may not be far from achieving this worthy goal.

4. CONCLUSION

One important goal in the teacher education program is to deliver to all future teachers the finest form of pedagogy in an authentic learning milieu that guarantees success and accomplishment. It is clear that there are diverse students as there are individual disparities among students in the normal classroom setting. In short, different learners possess different learning styles. Thus, teacher educators should teach having in mind the different learning styles of their students. Taking cognizance of the future teachers' preference for learning styles could be a step in the right direction for reducing learners' mathematics cognitive failures. By reducing the levels of

mathematics cognitive failures in future teachers could help to reduce the disparities due to learning style preference since the major goal is to achieve optimum teaching and learning with all future teachers. Teacher educators should do everything humanly possible to reduce future teachers' mathematics cognitive failures since high levels of mathematics cognitive failures may spell doom for future teachers' performance in mathematics. Strategies that could reduce future teachers' mathematics cognitive failures and close the gaps created by learning styles should be enacted to promote their success in mathematics learning.

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