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MODELING IN THE TEACHING OF MATHEMATICS IN JAMAICA: CHANGING ATTITUDE AND PERFORMANCE, IS THIS THE WAY FORWARD?

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ABSTRACT

INTRODUCTION: The performance of Jamaican candidates in Mathematics has generally been below expectations for decades; policy-makers, educators, scholars, and other stakeholders have sought to understand root of the problem, and to institute measures to address the performance deficit in Mathematics. There is no denying that we should place the teaching of Mathematics equally in any discourse, on the 'under-performance' of Jamaican students in the discipline.

OBJECTIVES: To (1) evaluate whether changing the human environment in a classroom can significantly alter the performance of students in Mathematics, (2) determine the attitude of students towards Mathematics,(3) examine the role of model-teaching in reducing the under-performance of Jamaican candidates in Mathematics, (4) determine whether students attitude changes with model-teaching, (5) and determine the students' attitude towards the teacher of Mathematics.

METHODS AND MATERIALS: The researchers employed ahybrid research design in the conducting of this research-a mixing of (1) causal design and (2) experimental design. A P value of $\leq$ 5% $(i.e. 0.05)$ was used to determine statistical significance and the data analysis took the form of descriptive, bivariate and multivariate statistics.

FINDINGS: A significant difference emerged between the mean scores for students in the Pre-Test Experimental group $(t = -1.842, P = 0.029)$, which was not the case in the Control group $(t = -1.832, P = 0.077)$.For the Pre-Test or the Post-Testin the Experimental group$(t = -1.884, P = 0.071)$ and Control Group on the Post-Test $(t = -1.330, P = 0.117)$, the overall attitude of the respondents towards Mathematics was very high, $135.5 \pm 25.7; 129.5 - 141.4$.

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CONCLUSION: Further study need to be conducted to determine the influence of Modeling on attitude toward Mathematics. The students' basic concept in Mathematics was limited.

KEYWORDS: Attitude towards Mathematics, Model, Mathematics, Under-Performance, GSAT, CSEC.

INTRODUCTION

Mathematics is one of the core courses (i.e. subjects) in the curricular of all educational institutions (Ministry of Education, Youth and Culture, 2011; Perie, Baker, &Bobbitt, 1997; Texas Education Agency, 2014; Truss, 2011). The primary purposes for the inclusion of Mathematics as a core course in the curriculum are (1) its value in critical thinking, (2) its building of reasoning skills, and (3) its development of problem-solving skills (Das, 2012; Felton, 2014; Quadling, 1982).

The core inclusion of Mathematics in the curriculum of all primary-to-secondary educational institutions in Jamaica is no different from what is present in other jurisdictions. Despite the widespread inclusion of Mathematics in the curricula of primary-to-secondary schools, there is a seemingly high level of difficulty in understanding the course and is possibly reflected in the non-success rate of candidates (Hall, 1930; Mwakapenda, 2008; Piasta, Pelatti, & Miller, 2014).

Generally, the performance of Jamaican candidates in Mathematics has been below expectations for decades. At the primary level (Grade 4), in 2009, 21out of every 50 candidates were successful in obtaining mastery in Mathematics. This declined to 19 out of every 50 in 2010. Although the success rate in Mathematics in 2015 represents a 13.0 percentage point increase over 2014, and a 6.4 percentage point decline in passes in 2016 compared to 2015, it can be deduced that there is a serious problem in Mathematics at this level (Table 1, Appendix A).

The problem of Jamaican students in Mathematics at the primary level is evident from the statistics of their performance in the Grade Six Achievement Test (GSAT). In a decade and a half, using statistics for GSAT results, at most 63 percent of Jamaican candidates successfully passed Mathematics at the grade six level (Table 2, Appendix A). In 2016, 57percent of the candidates who sat the GSAT examination was successful in Mathematics. Although the performance of students at the end of their primary level education in Mathematics is higher than that of their fourth year grade level, the results indicate a cause for concern in the discipline.

In similar fashion to that of the primary level, the under-performance of Jamaican candidates at the secondary level is of equal concern to policy makers. In the last one and a half decades $(2002 - 2016)$, the average pass rate in Mathematics of Jamaican candidates at the Secondary level (in CSEC) was41.2 ± 9.1 percentage points $(95\%\ CI: 36.2 - 46.3\%)$. Table 3 appendix A showed that the majority of Jamaican candidates who sat the CSEC examination were unsuccessful. Generally, over the 15-year period, the success rates in CSEC-Mathematics were lower than that which obtained at the primary level. In 2002, 16 out of 25 candidates were unsuccessful in the CSEC-Mathematic examination and this improved slightly to 19 out of 25 in 2004. For the 15-year period, only on two occasions (2014 and 2015) have the success rates surpassed 50 percentage points.

The under-performance of Jamaican candidates in Mathematics begs the question "What explains the dilemma in Mathematics performance among Jamaican students?" In 2007, Powell, Bourne and Waller, using stratified probability sampling design, surveyed 1,338 Jamaicans and found that education was identified as the third leading national problem. Education being a national problem in Jamaica like crime and unemployment is clearly "parceled" in under-performance of students in Mathematics. The Jamaica Ministry of Education, Youth, and Culture (2011) opined that:

In Jamaica, there are concerns about the unsatisfactory performance of students in Mathematics at all levels of the education system. The worries encompassing the low levels of performance comes from the acknowledgment that there are markers that an inadequate number of people in the general public are outfitted with the abilities and understandings required to work viably throughout everyday life and to apply the Mathematics they have learnt to new settings. One critical contributing component to the low levels of performance is the poor attitudes to the subject of numerous students and teachers.

The poor attitude of students is often compounded by the view a few students hold that the subject is of little use to them outside of school, especially since it is normally educated with an abnormal state of reflection increasing the issues caused by the distinction the general public has amongst mathematics and numeracy (p. 11)

The Jamaica Ministry of Education, Youth and Culture has singled-out attitude of students towards Mathematics as among the factors that influence performance in the course. If Mathematics is "…usually taught with a high level of abstraction" (Ministry of Education, Youth and Culture, 2011, p. 11), should attitude of the students be isolated and highlighted as a cause for concern? The Jamaican Ministry of Education aptly expresses the importance of Mathematics to human existence as:

Making utilization of Mathematics as a method for creating basic reasoning, critical thinking abilities and imaginativeness remains a subtle objective. For this to be accomplished, Mathematics should be educated, particularly in the early years, in a way that makes it formatively fitting to students as far as their individual status, social foundation, and passionate profile. The idea of the subject requires that when it is utilized to survey students' improvement, it be done in a way to underwrite the capacity of students to acknowledge and depend on it in their everyday exchanges (p. 9)

A critical question that needs to be answered is, "Is there something amiss with the teaching-learning process that is accounting for the under-performance of Jamaican candidates in Mathematics?" Clearly from the aforementioned perspectives, the Jamaican Ministry of Education has been somewhat placing the burden of the 'dilemma in Mathematics' at the feet of the students. Rightfully so, the students must account for their performance in courses and this is not different for Mathematics; but, "Is the teaching of the course an issue that must be examined?" Knowles, Holton and Swanson (2011) forwarded that "The social psychologists have taught us much about the effects of the human environment, especially the quality of interpersonal relations" (p. 117). Here, the human element-the instructor, teacher or facilitator-in the learning process, is considered a part of the equation. Knowles et al. perspective may hold answers to the under-performance of Jamaican candidates in Mathematics.

It is fitting, therefore, that with the 'dilemma in Mathematics performance' an examination of the human environment in Jamaica would offer some insights into the educational crisis. The Jamaican Ministry of Education, Youth, and Culture (2011) indicated that:

The strategy, which ought to be utilized in the instructing of Mathematics, has framed a basic premise in the development of the National Comprehensive Numeracy Program. The approach is embraced at the early youth and essential levels through the national institutionalized educational program, which puts substantial dependence on a way to deal with instructing and learning of Mathematics, which promotes the development of conceptual understanding, computational fluency, and problem solving skills.

These three components of sound Mathematics teaching are critical to an individual's ability to attain mastery in numeracy and they are best developed in a classroom context, which is student-centered, and in which there is a consistent effort to integrate practically, mathematical ideas with other subject areas (p. 11)

With the Jamaican Ministry of Education, Youth, and Culture indicating that the teaching of Mathematics plays a critical role in influencing students' performance in the discipline, the time has come for us to explore openly the teaching conditions.

An approach to teaching and learning which consistently links mathematical ideas to our everyday life and experiences is one way in which we can make learning the subject more interesting for students. This will mean that teachers will have to think about identifying activities that demonstrate the link between what is being taught and the current or future everyday experiences of their students (Jamaican Ministry of Education, Youth and Culture, 2011, p. 14)

Hence, the objectives of the current study was to evaluate whether changing the human environment in a classroom can significantly alter the performance of students in Mathematics; determine the attitude of students towards Mathematics; determine the students' attitude towards the teacher of Mathematics; examine the role of model-teaching in reducing the under-performance of Jamaican candidates in Mathematics; and determine whether students attitude changes with model-teaching.

LITERATURE REVIEW

THEORETICAL FRAMEWORK

The theory, Situated Learning, developed by Lave and Wenger (1991) reasoned that learning is a matter of creating meaning from real activities of daily living. This theory is an expansion on the work of Dewey, Gibson, Vygotsky, and Schoenfeld in which they postulated that students are more inclined to learn by actively participating in the learning experience. Brown, Collins, and Duguid in which they emphasize the idea of the cognitive apprenticeship model further developed the Situated Learning Theory (SLT). This "cognitive apprenticeship" supports learning in a domain by enabling students to acquire, develop, and use cognitive tools in authentic domain activity (Brown, Collins, and Duguid, 1989; Lave, 1988; Lave and Wegner, 1990; OTEC, 2007; Pappas, 2015).

Brown and colleagues stated that:

Cognitive apprenticeship attempts to promote learning inside the nexus of movement, apparatus, and culture that we have depicted. Learning, both outside and inside school, propels through shared social association and the social development of information (p. 40)

Arranged Learning Theory (SLT) recommends that learning happens through connection amongst individuals and interfacing earlier information with genuine, casual, and frequently unintended relevant learning (Brown, et al., 1989; Lave, 1988; Lave and Wegner, 1990). This showed learning is more viable when a student is effectively occupied with Mathematics instead of endeavoring to get information latently psychological apprenticeship demonstrates. The Theory of Situated Learning includes students in helpful exercises where they are tested to utilize their basic reasoning and sensation capacities (OTEC, 2007; Brown et al, 1989).This build speak to how the student part change from being a learner to a specialist as they turn out to be more dynamic and submerged in the social network where learning happens.

To test the Theory of Situated Learning, Lave led an investigation to take a gander at the performance on arithmetical assignment, estimated amid consistently shopping in the grocery store contrasted and an arithmetical test that scrutinized similar aptitudes. The outcomes on the test were more terrible than the arithmetical undertaking performed in the grocery store. Thus, she battles that when students gain learning outside of any relevant connection to the subject at hand aptitudes, they for the most part were not able apply them, in actuality, circumstances for which they were anticipated (OTEC, 2007).

Figure 1.Situated Learning Model

Clearly (Figure 1) situated learning involves actively participating in the learning-process by way of real daily activities (Stein, 1998; Pappas, 2015). The Situated Learning Model creates a replica of the real situation in the teaching environment. Stein (1998) went further and recommended the guidelines of classroom activities in the Situated Learning Model:(1) Knowledge is acquired situational and transfers only to similar situations; (2) “Learning is the result of a social process encompassing ways of thinking, perceiving, problem solving, and interacting in addition to declarative and procedural knowledge, and (3) learning is not separated from the world of action but exists in robust, complex, social environments made up of actors, actions, and situations” (para.3). For this study, Mathematics will be taught by way of the Situated Apprenticeship Model to a cohort of students at the primary level. The model incorporates behaviour of the student, the content of the material, activity of the classroom, and culture, which set the ideal framework of the teaching of Mathematics instead of the traditional teaching model (i.e. lecture method). The Situated Model brings the learner and teacher into a wider context than merely providing the material for instruction. In fact, it holds the key to a broader context of teaching that is multidimensional compared to the traditional teaching-method, and as such opens the gate for using modeling in the teaching of Mathematics.

MODELING AS A TEACHING STRATEGY IN MATHEMATICS

The question of 'problem solving' and 'critical thinking' is seldom mad dressed in Mathematics texts, and by teachers on a whole. In general, problem solving is seen as a task of solving algorithms. According to Jurdak (2016), traditional Math problems serve the purpose of giving students practice using computational skills in a context or a situation. This approach seldom addresses the issue of conceptual understanding, but focuses instead on allowing the students to practice a number of algorithmic problems, followed by a few word problems. Mathematics is a tool and a key to 'unlock' real world problem and should be taught as a tool. The application of Mathematics as a tool to solving real world problem is the key to developing critical thinking skills.

Problem solving is a process and as such, Mathematics as a problem-solving tool should be taught as a process. This problem-solving process is well articulated by George Polya. Polya (1945) outlined his four-stage approach as (1) Understanding the problem: What is the unknown? What are the data? What is the Condition? Is it possible to determine the unknown? On the other hand, is it insufficient, redundant, or contradictory? (2) Devising a plan: Have you seen it before, or have you seen the same problem in a slightly different form? Look at similar problems: Is there a theorem that may be useful? (3) Carry out the plan of the solution, checking each step. Are the steps correct? Can it be proven that the steps are correct? In addition (4) looking back: checking the results. Can we verified the arguments? Can the results be checked in a different way? Can the results be observed at a glance? Can the results or method be applied to another problem? In his elaboration on the problem-solving process, Polya (1945) suggested that many Mathematical results were found by induction first and proven later. He further opined that Mathematics presented with rigor is a systematic deductive science, but Mathematics in the making is an experimental inductive science. Polya further argued that Mathematics involves observation and induction to discover general laws, followed by rigorous proof. Modeling this approach across the educational landscape in the teaching of Mathematics is an obvious asset to the improvement of performance in Mathematics. Hersko and Herron (1999),argue, "Constructivism rejects the behavioral, reductionist arguments that lead to meaningless drill and isolated skill development. Authentic learning focuses on making instruction meaningful to the student by placing instruction in the context." Rivera (1997) as quoted in (Hersko & Herron, 1999) noted that a shift has been made to an application-based approach, where active student learning is rooted in problem solving situations facilitated by the teacher as a coach and questioner.

Modeling in Mathematics education has been applied across all educational levels as a means of developing the problem-solving aptitude of students (Erbas, Kertil, Cetinkaya, Cakiroglu, Alacaci, &Bas, 2014), and providing for the independent engagement of students in problem-solving (Sole, 2013). The application of modeling to Mathematics hinges on Mathematics as a language with multiple symbols and relations (Saxena, Shrivastava, & Bhardwaj, 2015). Modeling also hinges on Mathematics as a human activity with a relationship to reality (Arseven, 2015) which also extends to the utility of modeling in problem-posing(English, Fox, & Watters, 2005). The principle of modeling is to reduce a problem to a Mathematical structure (the model) and by using our knowledge of Mathematics, determine information about the model which can be interpreted as information about the problem (Fisk, 1975). It presents a more meaningful and permanent learning approach to Mathematics (Arseven, 2015). Mathematical Models are considered as mathematical representations of real world situations comprising a four-step process of designing a simplified version of the problem situation.(1) Constructing a mathematical model of the simplified version of the problem. (2) Identification of solutions within the framework of the mathematical model. (3) Interpretation of the solutions in terms of the simplified problem situation, and (4) Verification that the solution generated for the idealized problem are solutions to the initial problem (Hodgson, 1995). Similarly, Hernandez, Levy, Felton-Koestler, and Kbiek (2016) in a more scientific approach to the stages of modeling, identified five stages of identifying a problem: making assumptions and identifying variables, doing the math, analyzing and assessing the solution, iterating and refining the model, and implementing the model. There is support for the effectiveness of modeling as an instructional strategy in improving students' achievement in Mathematics (Doerr, Arleback, & Staniec, 2014; Firmender, Gavin & McCoach, 2014). The benefits of modeling Mathematics provides the opportunity to motivate students, eliminate learning anxiety, and develop a positive attitude toward the subject, alongside the cognitive benefit of problem-solving and real-life application (Arseven, 2015). Teacher' knowledge and pedagogical skills are considered instrumental in creating the type of learning environment, which will help students achieve proficiency in numeracy. This is achieved through investigation and problem-solving in hands-on experiences, which are authentic, relevant, and meaningful to the learner (Polly, 2008). The enthusiasm inherent in the use of modeling mathematical principles stem from the discovery of how observable phenomenon in nature can be explained in mathematical terms (Garrity, 2005).

Despite its problem-solving base, mathematical modeling differs from traditional problem-solving in that open-ended and multiple possible solutions are consciously developed based on the specifications of the problem, as opposed to the unitary correct solution of traditional problem-solving (Erbas, Kertil, Cetinkaya, Cakiroglu, Alacaci, & Bas, 2014; Sole 2013). The twinning of curricular changes and the professional development of curriculum developers and teachers is important in Mathematics modeling (Sole, 2013). Support for the development of teachers and program developers in the modeling of Mathematics have been justified by Arseven (2015). Arseven suggests the use of in-service education, the provision of learning materials and resource, and conducting research on teachers to establish their propensity for utilizing the modeling approach in teaching Mathematics.

DIFFICULTIES AND CHALLENGES IN TEACHING AND LEARNING MATHEMATICS

The difficulties in the teaching and learning of Mathematics stem from the interaction between teachers and students that makes for a synergy, which determines whether the desired outcomes are achieved. Cognitive, affective, and environmental factors contribute to differences in students' learning of Mathematics (Gafoor & Kurukka, 2015). The drive toward inclusive educational policies requires an examination of teacher's belief systems if such policy is to benefit students (Beswick, 2008). At policy level, it is recommended that consideration be given to students with difficulties learning Mathematics, since deficiencies in Mathematics learning affect economic growth and development and affect the benefits, which the learner can extract from society (Acar, 2012). From the students' standpoint, deficiencies in Mathematics competency and feelings about themselves play a role in their performance in the subject area (Acar, 2012). A comprehensive overview of the difficulties inherent in the teaching and learning of Mathematics is provided by Gafoor and Kurukka (2015). The major difficulties in students stem from challenges in remembering content learnt in earlier classes, remembering the learned material, and difficulties in understanding mathematical concepts. Gafoor and Kurukka (2015) further reported that teachers note the lack of effort and relevant pre-requisites in students as the major factors contributing to difficulties in learning Mathematics. In addition to these, the lack of motivation, reluctance to seek help, and inattention in class were also identified as causative factors. Mulwa (2015), in a mega analysis of the literature on difficulties, identified the following factors: (1) teacher qualification, (2) time spent in lesson preparation, (3) teaching methods, (4) frequency of supervision, (5) students' and teachers' attitudes toward Mathematics, (6) availability and use of media resources, (7) teaching experience, (8) class size, and (9) in-service training. The multiplicity of factors and their likely combinations make it difficult to pinpoint the source of insufficiency. Gafoor and Kurukka (2015) identified considerations for teaching and learning Mathematics effectively. These include: (1) revising the related previous content to ensure mastery before starting a new topic, (2) designing instruction in a manner that reduces cognitive load by prior development of relevant schema, (3) promote meaningful understanding and memory by structuring knowledge which is connected to previous content, (4) encouraging students to follow deep learning strategies so as to improve understanding and memorization, (5) instead of blind drill work, students should be given problems that promote meta cognition, (6) fine-tuning students' self-efficacy, and expectancy beliefs regarding Mathematics in order to increase effort, (7) providing clear curricular goals to students and helping them set their own goals, and (8) boosting students' confidence that their ability can be improved through effort, because effort is more important than ability.

ATTITUDE TO MATHEMATICS

De Lourdes Mata, Monteiro, and Peixoto (2012) led an examination to see how certain extraordinary, yet interrelated factors, for example, foundation, inspiration, and social help clarify students' attitudes towards Math and to pick up a comprehension of the characterizing attributes of these attitudes in the school condition. Members comprised of 1719 Portuguese students, from fifth-to-twelfth grade. The investigation used an adjustment of the "Inborn Motivation Inventory." One area of the poll "In my Math Class"- additionally surveyed student attitudes. The outcomes uncovered that as a rule, students held inspirational attitudes towards Mathematics, and featured the fundamental impacts of review and Math accomplishment regarding these attitudes. No sexual orientation impact was distinguished, despite the fact that the young ladies demonstrated consistent decrease in attitudes the further they advanced in school. A various leveled investigation utilizing basic condition displaying demonstrated that inspiration related factors are the primary indicators of attitudes towards Mathematics, and teachers. The social help of companions was considered exceedingly critical in understanding these attitudes.

PERFORMANCE IN MATHEMATICS

Wenglinsky (2001) directed a quantitative report to investigate the connection between classroom practices and student scholarly performance by applying multilevel displaying to the 1996 National Assessment of Educational Progress in Mathematics. This examination found that schools matter, since they give a stage to dynamic, instead of latent, teachers. Aloof educating enables students to perform inside the points of confinement of accessible assets to the instructor. It includes decreasing Mathematics to its least complex segments. All lessons are at a similar level of abstraction; problems are solved in a single step and required a single solution; and all students are treated as if they had entered the class with the same level of preparation and learning styles. Active teaching encourages students to grow regardless of their backgrounds. It does justice to the complexities of Mathematics. Lessons work at multiple levels of abstraction, from the most mundane problem to the most general theorem. Problems involve multiple steps and allow multiple paths to their solution; and teachers tailor their methods to the knowledge and experience of each individual student. Schools that lack a critical mass of active teachers may indeed not matter much. Students in this type of learning environment will perform at an average level in tandem with the resources available. In contrast, schools that do have a critical mass of active teachers can actually provide a true value-added benefit. They can help their students reach higher levels of academic performance than those students would otherwise reach. Through active teachers, schools can be the key mechanisms for helping students meet high academic standards.

METHODS AND MATERIALS

To gather information for this examination the specialists utilized the quantitative strategy. This device utilized exceptionally organized techniques, for example, polls, reviews, and organized perception. As indicated by Weinreich (1996), quantitative research utilizes techniques received from the physical sciences intended to guarantee objectivity and unwavering quality. These strategies direct that exploration members be chosen arbitrarily from the examination populace in a fair way, and the utilization of the institutionalized survey is utilized. The analyst is viewed as outside to the genuine research and results are relied upon to be replicable regardless of who directs the examination. For quantitative research, the scientists task of numerical qualities to reactions to gather information.

According to Tewksbury (2009) Quantitative research requires that one either simply study the counts of events/ people/ things or that numeric labels be created for meaningful events, experiences and actions. Tewksbury adds that without numeric labels on "variables" the quantitative scholar is unable to manipulate data and identify patterns.

It is in keeping with the aforementioned arguments that this research will employ a quantitative approach because of the objectives of the work. It will be a hybrid research design. The hybrid research design mixes (1) causal design and (2) experimental design. For the causal research design, the issue of 'why' will be established as it relates to attitude as well as other conditions and performance in Mathematics among a group of primary school students (Bachman, 2007. Beach and Pedersen, 2016; Brewer and Kubn, 2010). Data was collected and models were established as they relate to empirical association, and 'non-spuriousness'. The experimental research design allowed for the maintenance of a control of factors that are likely to influence an experiment-allowing for the experimentation with a control and an experimental group in order to determine the magnitude of a correlation (Anastas, 1999; California State University, 2006;Chow, 2010; Kirk, 2013; Trochim, 2006; Walliman, 2006).

SAMPLING FRAME

Stratified probability sampling technique will be used to drawn the sample (Cochran, 1963; Israel, 1992; Yamane, 1967; Kish, 1965). The formula for calculating the sample size (i.e. n) is $n = \frac{N}{1+N(e)^2}$ where n denotes the sample size, N is the population from which the intended study will be conducted, and *e* is the sampling error.

This formula was applied to compute the sample size. The sample size is 241 calculated based on a sampling error of 5%, a 95% confidence interval, and a student population of607 at the school (Table 4, appendix A). Students excluded from the study include grades 1 and 2.They had not been exposed to the content in the pre and post-test and therefore not in a position to understand the depth of the content to personally dislike the course. Therefore, the grades that are included are grades 3 to 6,owing to their understanding of their feelings and the fact that they would have taken a Mathematics test in either grade 4 or 5, or will be taking one in grade 3. The sample size of 241 in the study is based on the population in each grade. In making up the sample size, the researchers selected every third student in the population.

The sampling approach was however, later aborted and the entire student population from grades three to six was studied due to the unavailability of space to separate the sample population from the other student population. The researchers used systematic sampling to determine the final sample frame of 241 students for the experiment. This sub-sample was divided into two groups of 40 students for the experimental and the control group. With respect to gender distribution, the researchers selected 80 participants, equally distributed between males and females.

CAUSAL DESIGN

For the causal design, collection of data was based on the entire sample size of 241 respondents. The Instrument (i.e. Questionnaire) was used to collect relevant data from the sampled respondents (i.e. 241 students) in accordance with attitude towards Mathematics and their teachers of the subject. The questionnaire consisted of closed and open-ended items.

EXPERIMENTAL DESIGN

Experimentation involves research in which "…the researcher directly manipulates or controls one or more independent variables … and assesses their effects on the dependent variable" (Hair, Black, Babin & Anderson, 2010, p. 347). The experimentation involved a control group and an experimental group comprising of 40 students each. The experiment also included a pre-test comprising of 10 questions (Diagnostic Mathematics on fractions, comprising types of fractions, summation of fractions and equivalent fractions) and an attitude test comprising of 38 items including two demographic questions (Appendix C and D). Post-test consisted of 10 items (Appendix D).The post-test items included items on types of fractions, summation of fractions, and equivalent fractions.

PRE-TEST

Numbers were used to code each student and a test administered under examination conditions given at the start of the experimentation. An invigilation team consisting of available teachers ensured the integrity of the examination. The duration of the examination was 30 minutes. One mark was awarded for each correct answer and zero for every incorrect response.

POST-TEST

TREATMENT PROCEDURES

The two sub-groups of students (40 each) were subjected to experimental treatment involving the teaching of fractions. One group was exposed to traditional teaching methods and the second group to model in strategy. Traditional method of teaching Mathematics includes direct instruction in which standardized methods of calculation were taught in standard sequence and in isolation from its application to reality. The Math curriculum of the Ministry of Education determines the approach to traditional teaching method. Modeling in Mathematics refers to the use of Mathematics to interpret information about a problem (Fisk, 1975). The manipulative employed in the modeling method include the following:

1. Colour-coded rectangular plastic strips of equal length divided into factors of 60 (2,3, 4, 5, 6, 10, and 12) and are colour-coded (2 =

green, 3= yellow, 4 = blue, 5= purple, 6 = red, 10 = orange, 12 = pink
2. Circles, and
3. Paper-folding

The application of the manipulative to real-life scenarios will include dividing the sub-sample of 40 students into 10 groups of 4 students. Each group received a total of $400 (i.e. $100 per student). The following procedures employed for each concept included:

ORDERING OF FRACTIONS

Students received varying portions of the $400, and were required to identify the fractional value of each assignment and order the fractions from the highest to the lowest. Students will compare ordering within and between groups.

SUMMATION AND SUBTRACTION OF FRACTIONS

Each group identified from the allotted sum of $400, specific fractional amounts and used the concepts learnt to add and subtract by fraction from the whole ($400).

Pizza pies used, was divided into equal slices and students were asked to remove portions of the pizza and identify the fraction, which was removed, and what fraction remained.

TYPES OF FRACTIONS

Types of fractions was designated as, proper, improper, and mixed fraction. Following the treatments, both sub-samples completed a single test instrument, which comprised the following concepts:

1. Ordering of fractions
2. Sum of fractions
3. Division of fractions and
4. Types of fractions

The results were assessed for differences in performance between each subgroup.

DOCUMENTARY REVIEWS

The researchers reviewed written documents including books, journal articles, and company documents. The reviews determined: (1) theoretical framework, (2) items for instrument, (3) epistemological framework for the study, and (4) how to interpret the statistical analysis as well as the study. A major reason for the document review was to assist in triangulating[+] and validating information obtained in the interview, given that interviews *"rarely constitute the sole source of data in research"* (Johnson, 2001 in Gubrium and Holstein; 104: Bryman, 2001; 274: Hertz and Imber, 1995; ix) as well as framing the overall study.

ETHICAL CONSIDERATION

According to Bastick & Matalon (2004), there are four important principles that must be observed when conducting research. These are protection from harm, ensuring privacy and confidentiality, fair selection of participants and the need for informed consent.

In keeping with Bastick and Matalon's suggestions, researchers ensured the safety of the stakeholders, by ensuring that no identifying information is given. The researchers sought parental consent for the inclusion of their children in the sample. Respect for participants was duly given; as a result, information gathered was kept confidential. Researchers ensured the acknowledgment of information and data to avoid plagiarism, and fabrication of material.

[+]See Sevignty (1978) where he calls using a combination different viewpoints and methods 'triangulation'. In "A descriptive study of instructional interaction and performance appraisal in a university studio art setting: A multiple perspective. (Doctorial dissertation, The Ohio State University, 1977).Dissertation Abstracts International, 38, 6477-A.

The questions were set to ensure that participants could answer without causing them any emotional stress. The participants had the contents of the questionnaire read to them for clarification and understanding before being asked to respond to the statements. Letters requesting permission to conduct the research and to give information with respect to the purpose and benefits of the research were sent to the principal of the school involved in the survey.

INSTRUMENTATION

Survey was used to provide data for the quantitative aspect of this study, which allows for testing the theoretical model. A survey provides for the collection of a vast number of data on any issue and for cross comparison of the results of the current study against those in other geo-political areas (Powell, Bourne, & Waller, 2007). A questionnaire was the instrument of choice to gather data from students in large numbers. The questionnaire had mostly close-ended items written in English, as this is general language in Jamaica. There were 38itemson the instrument, with one being an open-ended item (Appendix C). The 'Diagnostic Mathematics Test' comprised of 10 multiple-choice items. The topic for this test included fractions, with the items covering equivalent to decimal fractions, and included three problem-solvingquestions-Ques.7, Ques. 9 and Ques. 10 (Appendix D).

FINDINGS

Table 5 presents the socio-demographic characteristics of the sampled respondents as well as descriptive statistics for the Attitude towards Mathematics Index and the Mathematics Test Scores. Of the sampled respondents $(n = 76)$, 86.8% $(n = 66)$ responded to the question on gender and this means that the non-response rate was 13.2% $(n = 10)$. The average age of respondents was 10.0 years ± 1.3 years, with a minimal skewness of -0.052, this means that age distribution is a relatively normal and so are the test scores.

Table 5.Descriptive Statistics of Socio-demographic, Attitude towards Mathematics and Mathematics variables

Details	**n (%)**
Gender of respondents:	
Male	35 (53.0)
Female	31 (47.0)
Age	10.0 years±1.3 years, 95%CI:9.7 years-10.4 years
Attitude Index toward Mathematics	
Mathematics score (overall):	
Pre-Test (out of 10)	4.8±2.7; 95%CI: 4.1-5.4
Post-Test (out of 10)	4.6±2.9; 95%CI: 3.9-5.3
Mathematics score (Experimental group):	
Pre-Test (out of 10)	4.6±2.5, 95%CI: 4.1-5.7
Post-Test (out of 10)	4.0±2.8, 95%CI: 3.0-5.1
Mathematics score (Control group):	
Pre-Test (out of 10)	4.9±2.9, 95%CI: 3.5-5.7
Post-Test (out of 10)	5.1±2.9, 95%CI: 4.1-6.0

PERFORMANCE IN MATHEMATICS BY GENDER

Figure 1 depicts the overall pre-Test performance in Mathematics of the students in the control and experimental group for the study. The Box Plot shows a greater score on the Mathematics Test for females (5.9 ± 2.9) compared to that for males $(4.1 \pm 2.)$. There is a statistical difference between the average score for females and males on the Mathematics Test $(t = -2.666, P = 0.010)$. This means that on average female got approximately two more correct answer on the Test compared to their male counterparts.

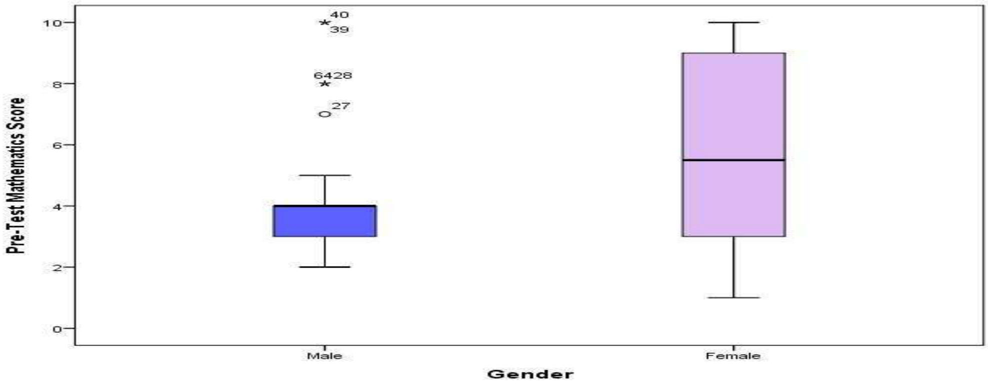

Figure 1.Box Plot of Pre- Test Mathematics score by Gender

Table 6 presents the descriptive statistics on the Post-Test result on the Mathematics Test for the sampled respondents. On average females obtained 5.7 correct responses from the 10 questions compared to 4.1 for males. Using Independent Sample t-test, there is a significant statistical difference between the two mean scores on the Test $(t = -2.215, P = 0.030)$.

Table 6.Post-Test Mathematics Score by Gender

Details	**Mean ± SD**
Gender	
Male	4.1±2.8
Female	5.7±2.9

Table 7 presents a disaggregation of the Mathematics scores based on group in which gender was the criterion used to choose the participants of the in the sample. A significant difference emerged between the mean scores for students in the Pre-Test Experimental group $(t = -1.842, P = 0.029)$. This was not the case for the Control group $(t = -1.832, P = 0.077)$, the Pre-Test or the Post-Test in the Experiment $(t = -1.884, P = 0.071)$ and Control Group on the Post-Test $(t = -1.330, P = 0.117)$.Such findings mean that for the Experimental Group on the Pre-Test, on average, females obtained higher scores than their male counterparts; but this was not the case for the Control Group on either the Pre-Testor Post Test as well as in the Experimental Group on the Post-Test.

Table 7.Post-Test Mathematics Score by Group (Experiment and Control) and Gender

	Experiment Group	**Control Group**
	Mean ±SD; 95%CI	**Mean±SD; 95%CI**
Pre-Test		
Male	3.9±2.0; 2.6-5.2	4.2±2.3; 3.2-5.3
Female	6.0±3.4; 3.9-8.2	5.8±2.6; 4.4-7.2
Post-Test		
Male	3.6±2.1; 2.1-5.0	4.5±2.9; 3.2-5.9
Female	5.6±3.3; 3.8-7.4	5.8±2.7; 4.4-7.3

Figure 2 depicts a scatter plot of the overall post-test and pre-test scores in Mathematics of the sampled respondents. On observing Figure 2, there is a clear linear relationship between pre-test and post-test scores in Mathematics, with the association being a relatively moderate one $(R^2 = 0.515)$.suchfindings indicate that the pre-Test performance in the discipline directly affects the post-Test achievement.

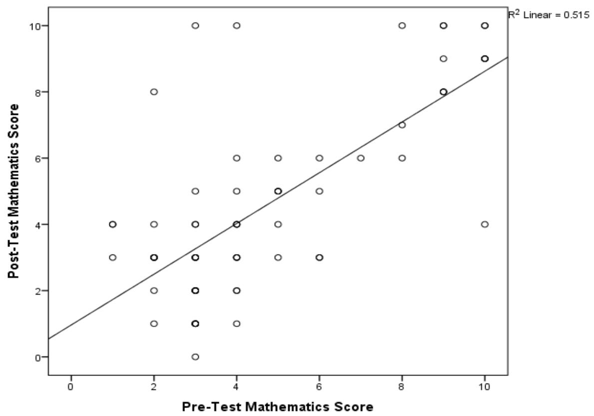

Figure 2.Scatter plot of Overall Post-Test and Pre-Test scores in Mathematics

Table 8 presents descriptive statistics on the Students' Attitude towards Mathematics Index. The overall attitude of the respondents towards Mathematics is very high, $135.5 \pm 25.7;\ 129.5 - 141.4$.However, when the combined attitude towards Mathematics Index was disaggregated into students' attitude towards mathematics and students' perception of their Mathematics teacher, the respondents indicated a very low attitude towards the teacher of Mathematics $-45.1 \pm 10.8;\ 42.6 - 47.5 -$ which was the reverse as it relates to their attitude towards the discipline, $90.7 \pm 16.6;\ 86.5 - 94.2$.

Table 8.Descriptive Statistics of Students Attitude towards Mathematics Index

Details	**Mean ± SD; 95%CI**
Students' Attitude towards Mathematics Index (SATMI)	90.7±16.6; 86.5-94.2
Students' Perception of their Mathematics Teacher (SPMTI)	45.1±10.8; 42.6-47.5
Combined Students' Attitude towards Mathematics Index (SATMI + SPMTI)	135.5±25.7; 129.5-141.4

Table 9 presents descriptive statistics for Combined Students' Attitude towards Mathematics Index by gender and group selection. No significant statistical difference emerged in the Combined Students' Attitude towards Mathematics Index and group selection $(t = 0.337, P = 0.737)$. However, a significant statistical difference existed between the genders at it relates to Attitude towards Mathematics $(t = -2.334, P = 0.003)$.

Table 9.Descriptive statistics of Students' Attitude towards Mathematics

Details	**Mean±SD; 95% CI**
Combined Students' Attitude Towards Mathematics	
Male	$129.9 \pm 24.3;\ 121.5 - 138.3$
Female	$143.23 \pm 23.4;\ 135.1 - 152.2$
Combined Students; Attitude Towards Mathematics	
Experimental group	$135.3 \pm 28.3;\ 126.0 - 144.6$
Control group	$133.2 \pm 24.6;\ 124.9 - 144.5$

Table 10 presents data on the OLS regression of combined attitude index and selected variables including Pre-Test Mathematics scores for the sampled respondents. An OLS regression examines linear relationship between one dependent and many independent variables. The assumption of linearity was upheld in this work $(F[3,51] = 10.767, P < 0.0001)$ as well as the issue of no multi-co linearity (Durbin Watson = 2.0). This means that the three explanatory variables linearly related to Combined Students' Attitude towards Mathematics scores. Although the assumption of linearity holds true for this work, disaggregation of the variables showed that only Mathematics scores influenced $(P < 0.05)$ attitude towards Mathematics and not gender or age of respondents (P > 0.05). Furthermore, a direct correlation exists between Mathematics scores and Attitude towards Mathematics and vice versa.

Table 10.OLS regression estimates of Combined Attitude towards Mathematics Index and selected variables including Pre-Test Mathematics score

	Unstandardized Coefficients		t-statistic	P value	95% CI		Co linearity Statistics	
	B	Std. Error			Lower	Upper	Tolerance	VIF
Constant	113.605	21.504	5.283	<0.0001	70.434	156.775		
Age	0.383	2.453	0.156	0.876	-4.540	5.307	.646	1.548
Male	-7.899	5.433	-1.454	0.152	-18.806	3.008	.883	1.132
Pre-Test Math Score	4.657	1.239	3.758	<0.0001	2.169	7.145	.587	1.704

DISCUSSION

The issue of performance in Mathematics in Jamaica has been a topical matter because of low achievement levels. In 2016, 52.8% of Jamaican candidates who wrote the Caribbean Secondary Examination Certificate failed the examination-achievinga proficiency of Grade IV to VI. Generally, over 15 years, the success rate has fluctuating from 23% to 48%.

However, in 2014 and 2015, the pass rate stood at 56% and 62%, respectively. This means that more Jamaican candidates have been unsuccessful in writing Mathematics at the CSEC level, which has implications for matriculation, and by extension, on national development.

For this study, the pre-test average score was 4.8 out of 10 compared to 4.6 out of 10 on the post-test, suggesting that intervention made no difference in the performance of the students.

The literature expounds that modeling is an effective method of improving performance in Mathematics (Arseven, 2015; Erbas, et al., 2014; Sole, 2013). According to Arsenven (2015), modeling presents a more permanent and meaningful approach to the teaching Mathematics. However, for this study, modeling did not make a difference, which would go contrary to the literature. The arguments forwarded by proponents of modeling are that cognitive, affective, and environmental factors significantly influence differences in students learning of Mathematics (Gafoor and Kurukka, 2015). This implies that the teachers' knowledge and attitude as well as class size are factors in determining students' performance in Mathematics (Mulwa, 2015). The current work revealed that students had a low perception of the teachers, affecting the delivery of the content in Mathematics and this explains the low performance of the students. Clearly, students are questioning the delivery of Mathematics by their teachers, as supported by the literature and this mitigates against high performance (Gafour and Kurukka, 2015).

Gafour and Kurukka (2015) indicated that students experience difficulty remembering learned concepts and that class size may attribute to the low performance in Mathematics (Mulwa, 2015). The present work revealed that the average performance in Mathematics was less than 5 out of 10 indicating moderate performance and this may be because of class size. It was revealed that the average class size was 45 and that many of the classrooms did not have available space for teachers to maneuver. As such, the teachers would not be able to adequately guide, coach and mentor the average performers. Despite the efforts and knowledge of the instructors and the instructional materials used, the class size is retarding the performance in Mathematics. Clearly, the large class size is undoubtedly influencing performance of the students, which is accounting for what is occurring in this work (Mulwa, 2015).

There is a correlation between attitude towards Mathematics and performance in Mathematics, (Acar, 2012; Gafoor and Kurukka, 2015), which is obtained in this work. According to de Lourdes et al (2012), students who had a positive attitude toward Mathematics were high performers, and this is concurred by this research. So why was there a low performance in Mathematics, within the context of a high attitude ratio? The answer to this question is simple; the multiplicity of factors influencing performance (de Lourdes, et al. 2012; Gafoor and Kurukka, 2015) and this account for what is unfolding in the current work.

Consequently, the following are recommendations based on the research carried out. From the results of students' attitude toward of teachers of Mathematics, it stands to reason that there is a need for embedded in-service training for the teachers and more external support for Mathematics coaching. Based on the result of the study, more contact time may be needed to allow students to grasp the basic concepts of Mathematics. A longitudinal approach in future study is recommended in order to ascertain the true value of modeling intervention and its effect on performance in and attitude towards Mathematics.

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APPENDIX

APPENDIX A

Table 1.Performance of Jamaican Students on Grade 4 Numeracy Examinations, 2009-2016

Year	%
2009	45.0
2010	38.0
2011	46.0
2012	51.0
2013	56.0
2014	54.0
2015	61.0
2016	57.1

Source: Ministry of Education, Youth and Information (2016).

Table 2.Performance of Jamaican Students on Grade Six Achievement Test (GSAT), 2009-2016

Year	%
2002	51.0
2003	48.0
2004	44.2
2005	57.8
2006	53.0
2007	46.0
2008	55.0
2009	53.0
2010	57.0
2011	62.0
2012	63.0
2013	61.0
2014	60.0
2015	56.0
2016	57.0

Source: Ministry of Education, Youth and Information, various years

Table 3.Performance of Jamaican Candidates on Caribbean Secondary Examinations Certificate (CSEC), 2009-2016

Year	%
2002	36.0
2003	36.0
2004	23.5
2005	39.4
2006	35.7
2007	35.3
2008	43.0
2009	40.9

2010	44.7
2011	39.9
2012	37.5
2013	42.2
2014	55.5
2015	62.0
2016	47.7

Source: Caribbean Examination Council (CXC), various years

APPENDIX B

Table 4.Population and Calculated Sample of the Studied Schools

	Population			**Sample**		
Details	Male	Female	Total	Male	Female	Total
Grade 3	70	75	145	28	30	58
Grade 4	64	70	134	25	28	53
Grade 5	85	61	146	34	24	58
Grade 6	102	80	182	41	32	72
Total	321	286	607	128	114	241

APPENDIX C

QUESTIONNAIRE (STUDENTS' ATTITUDE SURVEY-FOR MATHEMATICS)

The purpose of this questionnaire is to examine the relationship between mathematics performance and school-related factors and student-related factors. There are no correct or incorrect responses. Please read each item carefully and circle your response for each of the following options.

A. STUDENTS-RELATED FACTOR-STUDENTS' ATTITUDE TOWARDS MATHEMATICS

What is the relationship between students' attitude towards mathematics and their performance in mathematics?

No	**Items**	**SA**	**A**	**U**	**D**	**SD**
1	I am sure that I can learn math					
2	I believe mathematics is very difficult to learn.					
3	Taking mathematics is a waste of time					
4	I will use mathematics in many ways as an adult					
5	Knowing mathematics will help me earn a living					
6	I see mathematics as a subject I won't use very often when I finish high school					
7	Mathematics is not very difficult to learn					
8	I believe I can do well in math					
9	I'll need a good understanding of math for my future study					
10	If I try a little harder I know I will do well in math					
11	I'll need mathematics for my future work					

12	I am always nervous in mathematics class					
13	I feel that I have the ability to further my studies in mathematics					
14	I can get good grades in mathematics if I work harder					
15	I am not interested in mathematics.					
16	My mind goes blank and I am unable to think when solving mathematics.					
17	I enjoy doing mathematics.					
18	Mathematics is a subject I enjoy doing in school.					
19	I am afraid of doing mathematics					
20	Math has been my worst subject					
21	I only answer in mathematics class, if I am compelled to.					
22	I am anxious before mathematics tests.					
23	I prepare myself carefully for mathematics test.					
24	I feel good when I do mathematics quickly and accurately					

SA = Strongly Agree A = Agree U =Undecided D = DisagreeSD =Strongly Disagree

STUDENTS-RELATED FACTORS-STUDENTS' PERCEPTION OF THEIR MATHEMATICS TEACHER

What is the relationship between students' perception of their mathematics teacher and their performance in mathematics?

No	Items	SA	A	U	D	SD
	I believe my mathematics teacher:					
1	Explains the subject matter thoroughly					
2	Uses varied instructional materials when he/she is teaching					
3	Gives feedback regularly					
4	Shows no interest in teaching mathematics					
5	Does not include interesting actives and materials in his/her lesson					
6	Answers my questions clearly					
7	Has difficulty explaining certain concepts in mathematics					
8	Enjoys teaching mathematics					
9	Ignores me when I asked questions in class.					
10	Takes too long to mark my class work and test papers					
11	Is well prepared for his/her mathematics lesson					
12	Supports and encourages me.					

SA = Strongly Agree A = Agree U =Undecided D = DisagreeSD =Strongly Disagree

DEMOGRAPHIC CHARACTERISTICS

1. What is your age at last birthday? ____

2. What is your gender? Males:______ Female: ________

APPENDIX D

DIAGNOSTIC MATHEMATICS TEST (Pre-Test)

INSTRUCTION: Answer '**ALL**' questions. You may place a 'tick' or an 'X' is the appropriate option to indicate your answer to the question.

Ques. 1: What type of fraction is $\frac{2}{5}$?

a) Equivalent ◯
b) Mixed ◯
c) Proper ◯
d) Improper ◯

Ques. 2: Which fraction is a common fraction?

a) $\frac{1}{2}$ ◯
b) $\frac{3}{5}$ ◯
c) $\frac{3}{8}$ ◯
d) $\frac{5}{19}$ ◯

Ques. 3: What is $\frac{2}{4}$ the same as?

a) $\frac{1}{3}$ ◯
b) $\frac{2}{3}$ ◯
c) $\frac{5}{15}$ ◯
d) $\frac{3}{6}$ ◯

Ques. 4: The decimal number 0.25 is the same as:

a) $\frac{25}{100}$ ◯
b) $\frac{25}{1000}$ ◯
c) $\frac{25}{10}$ ◯
d) $\frac{25}{1}$ ◯

Ques. 5: What is $1\frac{1}{2}$ the same as?

a) $\frac{3}{4}$ ◯
b) $\frac{3}{2}$ ◯
c) $\frac{3}{1}$ ◯

d) $\frac{3}{3}$ ◯

Ques. 6: Which pair of fractions is NOT an equivalent fraction?

a) $\frac{3}{4}$ & $\frac{3}{8}$ ◯
b) $\frac{3}{4}$ & $\frac{6}{8}$ ◯
c) $\frac{3}{4}$ & $\frac{3}{9}$ ◯
d) $\frac{3}{14}$ & $\frac{3}{10}$ ◯

Ques. 7: What is the value for $1\frac{1}{2} + 2\frac{2}{7}$?

a) $3\frac{3}{9}$ ◯
b) $3\frac{3}{8}$ ◯
c) $3\frac{3}{10}$ ◯
d) $3\frac{11}{14}$ ◯

Ques. 8: What is $\frac{0}{2}$?

a) 2 ◯
b) 0 ◯
c) ∞ ◯
d) 5 ◯

Ques. 9: What is $1\frac{1}{2} \div 3\frac{3}{4}$?

a) $\frac{2}{4}$ ◯
b) $\frac{2}{6}$ ◯
c) $\frac{2}{5}$ ◯
d) $\frac{2}{3}$ ◯

Ques. 10: What is $4 - 1\frac{2}{5}$?

a) $2\frac{1}{5}$ ◯
b) $2\frac{2}{5}$ ◯
c) $2\frac{3}{6}$ ◯
d) $2\frac{3}{5}$ ◯

