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RE-DEFINED LEARNER'S ROLE IN INQUIRY-BASED LEARNING AND ACHIEVEMENT IN MATHEMATICS IN STEM-INTEGRATED SECONDARY SCHOOLS IN KENYA.

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ABSTRACT

One approach recommended to boost mathematics learning outcomes in Kenya secondary school mathematics is Inquiry Based learning (IBL) towards Competence-Based-Education (CBE).. Learner's participation in IBL lessons is dependent on defined roles that entail behavioral, attitudinal and cognitive expectations. This study investigated the effect of learner's actual-inquiry with focus on learner's roles on achievement in mathematics. It was founded on constructivism and sense-making learning theories to facilitate learner-centered practice and manage dilemmas encountered while implementing re-defined learner's roles. The study employed Quasi experimental design using Solomon-Four-Non-Equivalent-Control-Group with pretest-posttest, IBL as experiment and Regular Learning (RL) as control. Factor Analysis (FA) and Principal Component Analysis (PCA) examined suitability of tools, Cronbach-alpha 0.858 reliability for learner's participation tool. Means, composite percentages and regression analysis was used to examine trends and effect of learner's participation score on academic achievement. Findings revealed that learner's participation role significantly increased in IBL as compared to RL lessons characterized by passiveness. As a result, increased learner participation significantly predicted achievement in mathematics in favor of IBL. The study recommends that mathematics educators in STEM-integrated secondary schools need to grow professionally towards effective inquiry-based lessons with re-defined learners' roles. Moreover, the need for policy and practice to insure re-defined learner's roles in mathematics inquiry for effective implementation of CBE.

Keywords: Inquiry-based learning, academic achievement in mathematics and learner's participation role.

INTRODUCTION

The 21st century living demands individuals that are capable of undertaking strategic roles in solving real life problems, navigate the volatile, uncertain, complex and ambiguous (VUCA) environment. Learners that think critically, solve problems, are creative, collaborators and effective communicators are desirable learning outcomes aligned to the 21st century demands (Bachtiar et al., 2023; Fahrani et

al., 2023). Mathematics lessons that are either teacher-driven or examination-oriented with lessons characterized by passive learning prepare learners to be consumers and not producers of technical solutions. Contrary to the aspirations of the 2030 universal agenda emphasizing increased employable youth equipped with relevant technical and vocational skills, (UN, 2015) and capable of socio-economic transformation, learning processes are yet to position learners in an active problem-solving role. Learner's role is defined as behavioral, attitudinal and cognitive expectations in the Inquiry-Based Learning (IBL) context (Thornton & Nardi, 1975; Walker & Shore, 2015).

IBL is one of the pedagogical approaches recommended for Kenyan secondary school mathematics under the Competence-Based Education (CBE) curriculum. However, performance in mathematics subject remains below expectation especially ability to solve real life problems (Kenya National Examinations Council Reports, 2013-2020). IBL is a learner-centered approach that emphasizes active learner' participation in cognitive processes. Learner active participation in IBL lessons is dependent on clearly defined roles.

Pedagogical approaches employed in mathematics lessons either increase active learner participation or passive learning with both case scenarios determining academic achievement. The role of learners during inquiry-based lessons determine the extent of participation and academic achievement in mathematics. Walker & Shore (2015) asserts that creating opportunities for adopting diverse and varied roles happens often within inquiry classrooms stating that minimal levels of actual inquiry, resulted in diverse learner's roles.

Learner's participation roles in IBL need to be defined within the lesson plan framework and learner's work books in terms of individual, pair, group or plenary engagement. The challenge facing the constructive process of according learner's autonomy to think and explore with well-defined roles was generally compromised by incapacity, impatience and mis-guided priorities on the part of educators. Learners who understand self-roles and those of others as they undertake actual inquiry, attach meaning to learning tasks. This is contrary to conventional practice of teacher led discourse with passive learners. Re-defining roles positions learners in an active seat to intellectually engage in conceptualizing mathematics concepts.

Blair (2013) posit that intellectually engaged learners stay on task, view errors as learning opportunities and develop muscle to overcome emerging challenges. IBL mathematics lesson activities provide learners with varied participation roles that are intellectually engaging.

Effective implementation of inquiry-based lessons is anchored on planning activities with clear guidelines on the role of learners at each of the learning development steps. The prevalent one-size-fits all approach to teaching and learning predicates lessons to teacher-centeredness. An analysis of secondary database from the Programme for International Student Assessment (PISA) for Australia and Taiwan revealed that learner's role of explaining ideas and the teacher's role of explaining application of the ideas significantly and positively predicted achievement in mathematical literacy performance (Wang et al., 2022). Mathematical literacy is the learner's ability to formulate, employ and interpret mathematics in a variety of contexts. Active participation of learners' entail; asking questions, exploration of concepts, devising solution plans to problems, solving problems and discussing the tasks with others, this process enables learners to own the learning process resulting in retention and application of mathematical concepts.

The extent to which learner active participation in lessons is evident are dependent on the efficacy of the educator to prepare a variety of learning experiences that include open-ended problem scenarios that engage learners in individual, pair or group work to explore concepts.

The question of whether educators appreciate the need to position learners at the centre of inquiry mathematics by re-defining roles became relevant in this study. This is because, the experimental side of mathematics which is inductive entails; questioning, exploring and conjecturing, while the deductive involves; generalizing, structural analysis and proof (Blair & Hindle, 2019). Mathematics lessons in regular learning practices tend to favour the later where learners use a worked-out example to solve similar problem scenarios thereby missing an exploration opportunity to devise solution plans.

The study sought to fill this gap through re-defining roles to provide learners an opportunity to inductively explore the inquiry-based problem scenario. Beyond the individualized roles of learners on tasks, IBL engaged learners in collaborative activities working with peers either in pairs or groups to explore mathematical ideas (Artigue & Blomhøj, 2013; Fahrani et al., 2023; Lee et al., 2018; Staples, 2007; Walker & Shore, 2015).

When learners work together, to solve inquiry problem scenarios and discuss thinking processes with well-defined roles they gain new perspectives and insights that enhance understanding of mathematics. Learner's role in collaborating and communicating mathematical thinking contributes to achievement in mathematics. The benefits of learner's re-defined roles in IBL mathematics lessons include enhancing critical thinking about real life problem scenarios and mathematical concepts. Critical thinking positions learners in the role of questioning assumptions, analyzing evidence and evaluating solutions resulting in improved learning achievement in mathematics.

STUDY OBJECTIVE AND HYPOTHESIS

The objective of this study was to assess the effect of learner's role in actual inquiry context of IBL on achievement in mathematics scores in STEM-integrated secondary schools in Kenya.

The study was premised on the null hypothesis that there is no statistically significant difference in achievement in mathematics of learner's exposed to lessons focused on learner's role in actual inquiry context of IBL and those not so exposed.

REVIEW OF RELATED LITERATURE

Inquiry-based learning in mathematics emphasizes active learner participation, problem solving and critical thinking which are products of learner-defined roles at each stage of the lesson development An analysis of literature on inquiry-based education revealed more focus on the potential of IBL to enhance learning outcomes (Antonio & Prudente, 2024; Artigue & Blomhøj, 2013; Bachtiar et al., 2023; Walker & Shore, 2015). The influence of active learner participation with re-defined roles in the context of IBL mathematics lessons on academic achievement was an area of interest. A meta-analysis on the effects of inquiry-based approaches on learner's higher-order-thinking skills in science analyzed 1,349 learners exposed to IBL and conventional approaches revealing that regardless of educational level, scientific discipline, or level of inquiry, IBL positively enhances higher-order-thinking skills (Antonio & Prudente, 2024).

The quest to understand learner's roles in IBL that contribute to higher-order-thinking skills was of importance. in this study. Developing higher order thinking skills of learners to tackle real life problem scenarios was a product of active participation in lessons with well-defined roles on inquiry tasks.

The foregoing study on science, inspired the idea of investigating the case for mathematics subject by strengthening learner's role in IBL contexts. Active participation in individualized tasks to think and respond to the inquiry prompt, then pair to discuss responses, present harmonized responses to the class accorded learners adequate time to develop critical thinking, communication, collaboration and problem-solving skills.

Studies attest that engaging learners in lesson activities with defined roles lead to greater learning achievement. Literature revealed a proposed four-process inquiry framework that entails; exploration, engagement, stabilization and diversification roles (Walker & Shore, 2015). Arguing that inquiry lesson environment can pose anxiety to learners that are accustomed to regular learning processes in regard to changed expectations. Deliberate steps to guide the changed roles of learners and teachers during inquiry lessons has potential to mitigate such challenges. At exploration learners undertook roles such as individual initiative, collaboration and communication. Literature on time for learners to explore tasks has been shown to predict learning achievement in mathematics (Louw et al., 2008). Accordingly, a meta-analysis on inquiry-based learning effects of guidance to learners synthesized 72 studies with a view to compare effectiveness revealed facilitative effects of guidance on learning activities on achievement and learning outcomes (Lazonder & Harmsen, 2016). The process of exploration developed confidence to engage in inquiry roles such as questioning, listening, discussing, interpreting problem scenarios. Successful learner' engagement in inquiry roles resulted into stabilization process to undertake more challenging problem scenarios in mathematics inquiry. An investigation on learning experiences of 248 learners aged 11-16 years in Norway who were exposed to inquiry-based activities revealed that IBL had potential to foster positive perceptions towards mathematics in terms of being a creative and interesting subject (Pedersen & Haavold, 2023). However, the positive perceptions declined as learners progressed from primary to secondary school affecting more girls than boys.

Inquiry mathematics lessons tend to pose different and challenging problem scenarios. Role diversification entailed learner' active participation in undertaking greater and more varied roles that are not necessarily regular practice. In essence, role diversification in IBL refers to the expansion of the range of learner's roles in number and variety. Walker & Shore, (2015) on inquiry-role diversification asserts that it accords learners a sense of success during inquiry-based learning.

The practicality of role-diversification in a lesson can be challenging to implement if learning experiences are not well structured with lesson plans and learner's worksheets. An investigation using high order thinking questions and learner's worksheets to assess 73 learner's improvement after the use of IBL in mathematics classroom in a Nigerian polytechnic. The study revealed the use of IBL improved learner's High Order Thinking skills level (Abdurrahman et al., 2021). The improvement in learning outcomes was attributed to learner participation role in making generalizations from observations and analysis of worksheet tasks or examples. Despite the promising evidences obtained on the emergent role diversification occasioned by IBL, practice and impact of learner's participation role on achievement in mathematics remained unexplored. The transition from the prevalent teacher-centered confirmatory inquiry in mathematics lessons faced challenges of incapacity, perceptions and priorities.

The study reviewed literature on the application of two levels of inquiry namely; structured and guided inquiry that exposed learners to unique roles that are not common in regular practice. In structured inquiry, learners were given a question and illustrated method to solve to realize unspecified solution; while in guided inquiry learners were given a question only and expected to design a method to arrive at a solution (Bell et al., 2005; Blair, 2019). Learner's inquiry participation role in structured and guided inquiry deliberately designated tasks to be undertaken.

A structured learner's work sheet aligned to the lesson plan development steps described learner's role that supports active participation in the inquiry-based learning. The learners worksheet entailed inquiry questions that enhanced learner's independence and initiative under the facilitative guidance of the teacher using prompts (Blair & Hindle, 2019). A prompt in inquiry-based learning is a mathematical statement, equation or diagram loaded with potential for exploration. The inquiry prompt is characterized by intrigue to raise curiosity and questioning; slightly higher than learner's prior knowledge to draw the known while fostering a learning need. The prompt was open-ended to allow learners regulate activities while developing confidence to manipulate or explore; and promotes connections or linkages between various mathematics representations (Blair, 2015, 2023).

The forgoing potential of inquiry-based learning in enhancing learner active participation role was hindered by the traditional regular learning models of instruction.

Teachers experience challenges in preparing written lesson plans and learner's worksheet that support active participation in lesson discourse with clearly defined roles.

The relationship between learner's participation role in IBL and learning achievement in mathematics remained an area of interest because it is inadequately explored. The re-defined role of learners is an indicator of role diversification in an increasingly teacher-centered practices. An analysis of the dynamics of role acquisition in inquiry identified four stages namely; anticipatory, formal, informal and personal levels that are on a continuum from passive to active engagement (Wang et al., 2022). Learners transiting from confirmatory inquiry lessons function at the anticipatory role expecting to passively participate owing to regular teacher-centered activities. Designing lesson activities that stimulate individual learner's interest to undertake roles in inquiry learning of mathematical concepts was a delicate balance of expectations. In addition, the need to accord learners autonomy and responsibility that enhance ability to formulate questions to the presentation and validation of solution plans (Artigue & Baptist, 2012; Artigue & Blomhøj, 2013) while carrying out investigations, discussions, interpreting data and solving problems (Cairns, 2019; Pedaste et al., 2015).

Transitioning learners from passive in regular lessons to inquiry learning that demands individual, pair and plenary discussions through answering open-ended questions, explaining, asking questions, listening to peers, recording data and information, contributing to plenary discussions and presenting group reports was the pursuit of this study.

The facilitation role of teachers was found to moderate learner's differences between high, medium and below average (Appiah et al., 2022; Dobber et al., 2017) during plenary discussions to realize improved learning achievement in mathematics. The think-pair-share strategy designated individual learners to think about and explore the given question and procedure in the case of structured inquiry, and the question to design the solution procedure in the guided inquiry level. At pair work learners had a responsibility to compare work while reflecting on the expectation of the mathematical question. The review of literature revealed inconsistencies in regard to focus on learner's dynamic role in IBL context with potential to influence academic achievement in mathematics. Therefore, the study hypothesized that there is no statistically significant difference in learner's achievement in mathematics of learner's exposed to lessons focused on learner's role in actual inquiry context of IBL and those not so exposed.

The study assessed the effect of learner's role in IBL context on learning achievement in mathematics.

METHODOLOGY

The study adopted the quasi-experimental research design to gather, process, analyze and interpret required data and information in response to the study objectives. Quasi-experimental research design was selected for its appropriateness in gathering qualitative and quantitative data and the causal hypotheses through manipulation of one or more independent variables to determine effect on the dependent variable without using random assignment (White & Sabarwal, 2014). Solomon Four Non-Equivalent Control Group (SFNECG) pretest-posttest design was used to control for equivalency among study groups, intervening variables and implementation of IBL because they were research as intact classrooms. Two experimental groups were exposed to inquiry-based learning focused on learner's roles during the actual inquiry. Two control groups were exposed to the conventional or Regular Learning method.

The design assessed the effect of experimental treatment relative to control condition and interaction between pre-test and treatment condition. The design assessed the effect of pre-test relative to no-pretest and homogeneity of groups before treatment. Geographical considerations minimized social interaction threats between experimental and control groups. As shown in Figure 1, X represents the treatment variable IBL approach, while C represents control condition the conventional Regular Learning (RL) approach. O_1 and O_3 were pre-tests, while O_2, O_4, O_5, O_6 were post-tests.

Random Assignment	Pre-test	Treatment	Post-test
Group 1: Experimental pre-test	O_1	X	O_2
Group 2: Control pre-test	O_3	C	O_4
Group 3: Experimental no pre-test		X	O_5
Group 4: Control no pre-test		C	O_6

Figure 1: Solomon Four Non-Equivalent Control Group Design, (Solomon, 1949; Campbell & Stanley, 1967***; Lavanya Kumari, 2013)***

The study targeted thirty-three thousand three hundred and seventy-two (33,372) form three learners in STEM-integrated secondary schools in Kenya because they had been exposed to the STEM-integration programs that included IBL for at least two years. The unit of analysis were form three learners taught by trained teachers of mathematics. Two hundred and ten (210) learners both boys and girls in the randomly sampled form three class were considered a suitable sub-set of cases used to draw conclusions on the population (Orodho, et al,

2016) of learners in STEM-integrated secondary schools in Kenya.

The research instruments as fact-finding strategy (Annum, 2017) were designed based on the study objective. The Mathematics Achievement Test (MAT) as the main tool, Learner's participation Questionnaire (LQ) and Lesson Observation Guide (LOG) were used to elicit responses. The MAT consisted of real life problems that were structured on the topic of trigonometry developed in reference to a table of specifications that entailed; trigonometry sub-topics, concept to be tested, Bloom's Taxonomy level of learning domain (Anderson and Bloom , 2001) , and the IBL indicator of focus for a given set of questions. Section I composed of compulsory short answer question of less than four (4) marks and section II of 10 marks' questions customized from the Kenya National Examination Council (KNEC) standard papers. Content validity of MAT was determined by mathematics experts namely; teacher trainers, practicing teachers and national examiners with the Kenya National Examination Council (KNEC). A Learner's participation Questionnaire (LQ) was used to measure the effect of learner' self-assessed participation in lesson activities focused and aligned to the indicators of IBL with learner participation roles defined. The LQ assessed learners 'participation role in lessons using a five-point Likert-type scale with 32 items on the indicators of IBL.

A Lesson Observation Guide (LOG) was used to obtain firsthand information based on study objectives (Annum, 2017; Roller & Lavrakas, 2015) on learner's participation role in IBL and the conventional Regular Learning (RL) lessons. The tool tracked implementation and focus on indicators of IBL and related effect on achievement in mathematics. LOG gathered information that enlightened inferences on relationships between learner's participation role and achievement in mathematics..

The study was introduced to the groups through school visitation, engagement with the school leadership and selection of teachers that met the set criteria. In the first two weeks, teachers of mathematics from the two experimental groups were trained on IB using an implementation manual prepared to include lesson plans developed in consultation with teachers to cover all the twenty-one recommended lessons for the topic of trigonometry. A three-day induction for teachers of mathematics from the two control groups on the study and expectations was also done by the researcher. The pre-test was conducted in the fourth week by the researcher and the teachers of mathematics in respective schools through administration of the LQ and MAT. Week five to nine were dedicated to the treatment in the two experimental groups and regular learning in control groups both covering the topic of

trigonometry taught in form three based on the Kenyan syllabus.

The lesson structure in experimental groups entailed; teacher-led introduction posing a designed inquiry question to review prior knowledge. Learners worked individually on the inquiry question, paired to discuss response; teacher facilitated plenary discussion and guided harmonization of the responses. Lesson development entailed teacher posed Key Inquiry Question (KIQ) aligned to the lesson objective, issued the learner worksheet and supervised actual inquiry activities. Learners documented worked out steps either in notebooks, sticky notes or manila papers for presentation and explanation using a variety of media to enable cross-pollination of ideas and learning. Learner's presentations were followed with plenary discussions with a view to harmonize responses to enable learners make conclusions. The KIQ was revisited at the conclusion step and learners given another opportunity to explain the responses and applicability of the concept. Finally, learners engaged in related evaluation activities.

The lesson structure in control groups entailed the teacher introduced the topic, worked out one or two examples while learners took notes, engaged learners in supervised exercises on related questions mainly from textbooks and concluded the lesson by assigning similar questions for further practice. Ten lessons in each of the two experimental groups were observed and 5 lessons in each of the control groups were observed giving a total of thirty lessons. In each case debriefing sessions were conducted with the observed teacher. In week ten, a posttest was administered to the learners after the lesson observation period in all the study groups.

RESULTS AND DISCUSSION

The collected data was analysed using the Statistical Package for Social Sciences (SPSS) version 24. Descriptive statistical analysis was conducted to identify overall trends in learner's participation score in IBL and RL lessons on the specific indicators and related achievement in mathematics. Re-defined learners' roles during IBL lessons enhanced active participation and learning achievement in mathematics. 81% of learners in IBL compared to 73% in RL groups indicated that lessons that defined roles in group activities improved participation and achievement in mathematics. The data for learner's participation role in actual inquiry indicator of IBL were statistically analysed at alpha = 0.05 significance level using descriptive statistics of mean, standard deviation and independent sampled t-test.

Two groups under IBL and RL conditions were pre-tested before the intervention to determine homogeneity level and post-tested after to assess the effect of the intervention. Independent sampled t-test statistic was applied to assess whether or not post-test scores were statistically significant. T-test established significant differences between IBL and RL groups. Independent-samples t-test was conducted to determine whether learner's participation role in actual inquiry indicator of IBL approach was more effective in improving learner's participation and achievement in mathematics than RL approach. The results are shown in Table 1.

Table 1: Independent Sample t-test, learner's participation role in actual inquiry indicator of IBL and achievement in mathematics

Independent Samples Test		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Learner's participation role in Actual Inquiry IBL Score - Posttest	Equal variances assumed	.266	.608	3.027	59	.004	8.304	2.743	2.815	13.792
	Equal variances not assumed			3.024	58.146	.004	8.304	2.746	2.808	13.800
MAT Posttest Percentage *Group 1 (IBL) & 2 (RL)*	Equal variances assumed	.168	.684	2.166	56	.035	7.828	3.613	.590	15.065
	Equal variances not assumed			2.166	55.994	.035	7.828	3.613	.590	15.065
MAT Posttest Percentage *Group 3 (IBL) & 4 (RL)*	Equal variances assumed	6.434	.013	2.775	81	.007	8.998	3.242	2.547	15.449
	Equal variances not assumed			3.041	76.546	.003	8.998	2.959	3.105	14.891

Table 1 data revealed statistically significant mean difference in learner's participation role in actual inquiry indicator of IBL approach compared to RL at ($t\ (59) = 3.027$, $p<.05$). The findings also revealed that the mean difference in mathematics achievement test scores between groups 1 (IBL) and 2 (RL) were statistically significant ($t\ (56) = 2.166$, $p<.05$). In addition, data shows statistically significant mean difference in mathematics achievement test score between groups 3 (IBL) and 4 (RL) at ($t\ (81) = 2.775$, $p<.05$). The significance level was stronger for groups 3 and 4 who only post-tested as compared to groups 1 and 2 who underwent pre and posttest.

Lesson observation documented learning outputs from individual, pair or group work that demonstrated the effectiveness of redefined learner's role. Learners demonstrated responsibility during actual inquiry and documented observations as shown in Figure 1 below. Figure 2 shows an example of the product of learner's defined role on assigned tasks working in pairs during a gallery walk inquiry lesson activity.

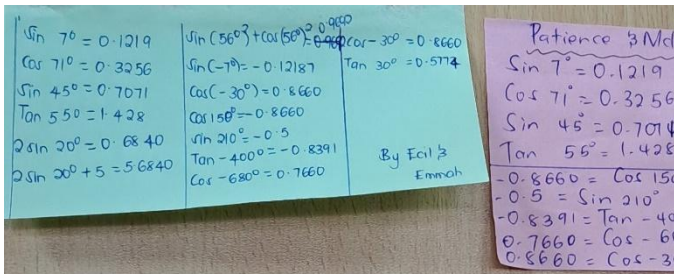

Figure 2: Learner's outputs on assigned roles during a gallery walk inquiry lesson activity

The implication was defining learner's role during actual inquiry activities in IBL lessons enhanced active participation which in turn improved mastery of concepts and achievement as reflected in mathematics test scores as compared to RL lessons where learners were passive. Hence the null hypothesis that there is no statistically significant difference in learner's achievement in mathematics of those exposed to lessons focused on learner's participation role in actual inquiry and those not so exposed is rejected. The alternative hypothesis that lessons focused on learner's participation role in actual inquiry indicator of IBL significantly predicted achievement in mathematics as compared to regular learning.

Learner's participation role in actual inquiry indicator of IBL was found to have significant effect on mathematics achievement scores that tested the ability to solve real life problem.

The independent sampled t-test revealed significantly improved learner participation role in IBL that was higher than regular learning lessons. Accordingly, the independent sampled t-test showed that mathematics achievement test scores for IBL group 1 (pre-tested & post-tested) was significantly higher than RL group 2 (pre-tested & post-tested).

In addition, mathematics achievement test score for IBL group 3 (post-tested) was significantly higher than RL group 4 (post-tested). Further observed that the significance level was stronger for groups 3 and 4 (post-tested) as compared to groups 1 and 2 who underwent pre and posttest. The implication was that IBL lessons with focus on learner's participation role enhanced active involvement in inquiry activities that improved mastery of concepts. As a result, learners were able to solve real life problems in mathematics.

Apparently, learners understanding of self-roles and those of others in IBL lessons enhanced active participation in actual inquiry resulting in improved learning achievement in mathematics. The contrary was true for regular learning with whole group instruction, teacher telling and learners passively taking note of examples or doing supervised exercises.

The finding is in line with the assertions of Blair, (2019) that intellectually engaged learners with defined roles stayed on task, questioned deviations, viewed errors as opportunities for learning and overcame challenges that resulted in improved abilities in solving real life problems. The finding agrees also with the study results of role diversification that accorded learners a sense of success in undertaking assigned tasks (Walker & Shore, 2015) owing to clarity of roles. Defined roles entailed clarity on individual, pair, group or plenary lesson tasks as guided in both the lesson plan and learner's worksheet. The lesson plan indicated teachers and learner's roles at each of the lesson development stage. For instance, at introduction stage the plan stated that, "*the teacher presents the activities and learners use the think-pair-share strategy to respond by working individually, then in pairs and plenary discussions*".

CONCLUSIONS AND RECOMMENDATIONS

The findings of this study have shown that learner's participation role in actual inquiry indicator of IBL significantly increased active involvement in lesson activities than the RL lessons which were characterized by passive learning. The study revealed that defined learner's participation role in IBL resulted in higher mathematics mean score than regular learning and the difference was statistically significant.

Learner's participation role in IBL lessons strengthened intellectual engagement in investigating relationships between sides and angles of a triangle, solutions as well as general trends to arrive at theorems. Using self-developed theorem made logical sense resulting in mean differences in mathematics achievement scores for learners exposed to IBL as compared to those in RL. Lessons provided an exploratory experience that inculcated logical and meaningful learning through key inquiry questioning, with defined learner roles.

Based on the study findings, it is recommended that teachers facilitate well defined roles during inquiry lessons to enhance intellectual engagement of learners in exploring mathematical concepts. Learner's participation roles in IBL need to be defined within the lesson plan framework and learner's work books in terms of individual, pair, group or plenary engagement showing inquiry tasks. Transitioning learners from passive in regular lessons to inquiry learning that demands answering open-ended questions, explaining, asking questions, listening to peers, recording data and information, contributing to plenary discussions and presenting group reports need to be evident in mathematics inquiry lessons.

In addition, teachers need periodic and regular training, mentorship and coaching to effectively implement role diversification required in inquiry-based learning and according learner's autonomy to think and explore with well-defined roles. Additionally, there is need for policy and practice to enforce re-defined learner's roles in mathematics inquiry for effective implementation of the competence-based education in STEM-integrated schools.

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