INQUIRY-BASED LEARNING AND MATHEMATICS ACHIEVEMENT: DOES LEARNER'S INDIVIDUAL PRIOR-KNOWLEDGE COUNT?

[1]Mary W. Sichangi; [2]Boniface Ngaruiya, [3]Paul A. Odundo; [4]Evanson M Muriithi;
[1-3] University of Nairobi.

[1]mnswakhaya@gmail.com, [2]bngaruiya@uonbi.ac.ke, [3]odundopaul@yahoo.com, [4]evanson.muriuki@uonbi.ac.ke

ABSTRACT

Performance in mathematics as a foundational subject to majority of scientific disciplines continues to remain below expectation especially ability to solve real life problems. This study investigated the effect of learner's individualized-prior-knowledge in IBL on mathematics achievement. A survey on 106 form three learners was conducted using a lesson observation guide and learner's participation questionnaire. Review of empirical data assessed effect of prior-knowledge on learning achievement. Engaging learners in IBL and capturing individualized prior-knowledge to design learning experiences enhances mastery of concepts. Study was founded on constructivism and sense-making learning theories to facilitate learner-centered practice and explore IBL to manage dilemmas when individuals encounter gaps between prior-knowledge and proposed change respectively. Factor Analysis (FA) and Principal Component Analysis (PCA) were used to examine suitability of study tools. Means were used to examine IBL practice and Pearson correlation coefficient and regression analysis assessed effect of individualized-prior-knowledge on achievement scores. Findings revealed learner's individualized-prior knowledge, significantly predicts mathematics mean score, rejecting the null hypothesis. Capturing learner's individualized prior-knowledge in IBL lessons influences mastery of concepts and mathematics scores. Mathematics educators need to assess individualized-prior-knowledge to design IBL learning experiences that support mastery and achievement. Policy recommendations on mathematics inquiry need to enhance prioritization of resources for training teachers and educators on the role of individualized prior-knowledge as a predictor of mathematics achievement.

Keywords: Inquiry based learning, mathematics achievement, prior-knowledge,

INTRODUCTION

Policy documents and research studies indicate that education should help learners engage actively and reflectively on what they already know in relation to new concepts in order to realize meaningful learning. An analysis of various studies on conditions for transfer of prior-knowledge indicate that if learning is well designed education can afford learners an opportunity for abundant transfer in terms of reflexive and mindful mechanisms. Accordingly, a meta-analysis of transfer of learning in mathematics selected studies that measured transfer using performance-based assessments revealed that effective transfer of prior-knowledge is a product of the right conditions for learning (Rayner, Benard & Osana, 2013). The Kenyan education system aspirations indicate that effective delivery of a Competence-Based Curriculum (CBC) needs to capitalize on unique learner's needs by using a variety of strategies to assess prior-knowledge in terms of knowledge, skills, values (RoK, 2017).

The curriculum framework prescribes learner-centered pedagogies that include inquiry-based learning aimed at enhancing learner's capacity to use prior-knowledge to think, generate hypotheses, evaluate evidence, analyze arguments and solve problems. This is in contrast with the approach of teacher telling learners by way of a mathematics question or problem, demonstrate the method and solution steps to passive learners which results into rote learning and reproduction after the teacher. The need to inculcate learner's active self-assessment through individualized mathematics learning activities that allow one to reflect on prior-knowledge, record own ideas, discuss and reason with others. This process enables learners to self-assess, review misconceptions while accommodating new ideas from class discussions.

The one-size-fits all practice to teaching and learning in most mathematics lessons tend to overlook the fact that learners have different kinds of minds. This practice fails to capture individual learner's prior-knowledge and confirm shared meaning of key terms that otherwise form the basis for mathematics lesson development. The Gardner's multiple intelligence theory reiterates that learners learn, remember, perform and understand in different ways (Morgan, 2021). Gardner defined an intelligence as a person's ability to solve a problem or do something considered valuable in one or more cultures (Ibid). Thus, lessons that deliberately assesses individual learner's prior-knowledge through a variety of learning experiences accord learners more opportunities to acquire and apply mathematical knowledge and skills. The implications therefore is the need to adopt personalized learning strategies that demand investment in adequate planning of a variety of learning experiences. Strategies such as prior test scores, Think-Pair-Share, group work, individual thinking time, computerized simulations and learning software have the potential to motivate learners to critically think about mathematics concepts. Learning experiences that are designed based on learner's ideas tend to reflect prior-knowledge and understanding that support lesson development.

IBL is a learner-centered approach that capitalizes on learner's prior-knowledge. It is founded on the constructivist theory of learning that emphasizes the process of active learner' involvement in cognitive processes set in social environments to construct understanding of mathematics concepts (Lister, 2015). IBL has potential to transform an individual's lifelong learning journey, because it motivates development of individual explanations based on prior-knowledge to resolve perceived knowledge gaps. IBL engages learners using planned individualized tasks that capitalize on prior-knowledge in order to make sense of mathematics concepts, (Ernst et al., 2017). There is however, inconsistencies in practicing IBL that takes time to assess learner's prior-knowledge in mathematics lessons owing to other competing priorities such as, preparing learners for national examinations. A meta-analysis of various studies on the definition of IBL distinguished between levels of inquiry indicating that they depend on amount of information given to learners (Bunterm et al., 2014).

The four conditions of inquiry levels therefore entail; confirmatory where the question, method and solution plan is demonstrated, structured the solution plan is not given, guided only the question is given and open learners generate the question, method and solution plan. The degree to which learners are engaged using the inquiry levels are determined by the educator's self-efficacy. As a result, lesson practice depicts aspects of more than one level of inquiry and important constructs such as learner's prior-knowledge are sometimes ignored. Individualized prior-knowledge as an important construct in IBL and how it influences learner's mathematics achievement scores is the focus of this study.

Research on mathematical inquiry has received inadequate focus as compared to science inquiry.

A recent study examined the effect of IBL on secondary school learner's self-efficacy in chemistry in Kenya revealing strong positive correlation (Mueni et al., 2023). Inquiry in mathematics however has been shown to increase conceptual knowledge and enhance deeper understanding that improves achievement (Marshall et al 2017). This study sought to relate a critical construct of inquiry-based learning to learner's mathematics achievement scores. Prior-knowledge in the context of mathematics inquiry is described as the process of assessing learners individualized knowledge, skills and values to inform the use of learning experiences that enhance mastery and hence mathematics achievement scores. The relationship between prior-knowledge in the context of mathematics inquiry and learner achievement takes a closer look at the influence of individual learner's mathematics score in Kenya Certificate of Primary Education (KCPE) and two year annual scores. KCPE mathematics scores were the learner's individual prior-knowledge that formed the basis for learning high school mathematics. KCPE is a national examination that marks the end of primary education in Kenya and used as an entry score to secondary school. Educators in the STEM-integrated secondary schools in Kenya were introduced to inquiry-based learning (CEMASTEA, 2017) and the study traced lessons taught by trained teachers. Learners in form three class were considered more experienced in the IBL practice with several mathematics annual scores.

For the purpose of this study, inquiry-based learning is defined as learner-centered investigative lessons that use questions to investigate mathematics concepts, explain meanings, apply knowledge and self-evaluate. Individualized prior-knowledge refers to pre-existing knowledge, skill, values or experience unique to each learner and relevant to a mathematics lesson. Mathematics achievement entails mastery of concepts, ideas, perceptions and ability to solve real life mathematics problems.

STUDY OBJECTIVE

The objective of this study was to assess the effect of individualized prior-knowledge in the context of IBL on mathematics achievement scores of learners in STEM-integrated secondary schools in Kenya. The study was premised on the null hypothesis that, there is no statistically significant influence of learner's individualized prior-knowledge on mathematics achievement.

REVIEW OF RELATED LITERATURE

Assessing learner's prior-knowledge in the context of mathematics inquiry determines individual learner's ideas, initial understanding and reveals learning gaps. Studies on inquiry-based mathematics education have situated learner exploration of text, materials, situations and events (Artigue & Baptist, 2012) as an initial step that reveals prior-understanding to inform inquiry. Thus, assessment of learners' prior knowledge constitutes the engagement phase of inquiry-based learning (Artigue & Blomhøj, 2013). Understanding learner's prior-knowledge creates fertile ground to engage in inquiry mathematics. Prior-knowledge serves as a basis upon which learners are invited to work like mathematicians to observe, question, interpret and self-evaluate solutions (Dorier & Maass, 2020). It is important to note that assessing prior-knowledge need to be individualized because each learner is unique.

Individualized prior-knowledge entails assessing or probing and capturing each learner's ideas, initial understanding, and learning gaps. This calls for deliberate use of strategies that solicit information from all. It is a departure from the common practice of asking questions that afford to capture ideas from a few high achieving learners or ignoring to use test scores altogether. In support, (Gnagey & Lavertu, 2016) found out that learner's prior test scores had positive effect on achievement. Test scores determined extent of learner's understanding of concepts. In addition, inductive approaches of learner' engagement through Think-Pair-Share (TPS) strategy using a key question strengthens critical thinking and mastery of concepts. A study on using the TPS strategy and a series of tests namely pre, post and delayed post-test resulted in improved mean achievement scores and knowledge retention (Lee et al., 2018). This underscores the importance of capitalizing on individual learner's prior knowledge as a basis for construction of new knowledge.

The importance of pair, group or class discussion are underscored by various studies indicating that they reveal individual learner's prior-knowledge and improved achievement in mathematics.
In IBL learners are able to interpret and discuss meanings while making connections to relevant mathematical knowledge, develop high order thinking and improved achievement (Kandil & Işıksal-Bostan, 2019). Discussions reveal individual learner's prior-knowledge on the concept under study and comparisons of ideas result in modification to accommodate and achieve improved understanding. An investigation of the influence of group discussions in inquiry-based learning on individual learner's understanding of science concepts revealed positive findings in regard to improved understanding and reasoning (Warfa et al., 2018). This is because pair or group discussions helps clarify individual understanding of mathematical concepts and where necessary modify conceptualization.

Moreover, an investigation on how different types of prior-knowledge influence 202 mathematics learner's achievement using prior-knowledge test scores and a final grade on the course revealed critical insights for this study (Hailikari et al., 2007). The study confirmed that the type of prior-knowledge makes a difference; procedural knowledge predicted the final grade while declarative knowledge did not predict final grades. Success in previous study predicted success of student achievement in the final grade on the mathematics course. In addition, the emphasis for learners to explore before explanation in inquiry-based learning further confirms the need for learners to make sense of mathematics concepts based on prior-knowledge (Ecke & von Renesse, 2017). The implication is that designing learning experiences should be informed by the type of individual learner's prior-knowledge.

Learning needs to be differentiated to capitalize on varied individual prior-knowledge that learners bring to the lesson. Deliberate efforts to analyze performance of test scores leads to successful inquiry and mathematics achievement.

In summary, the foregoing review of literature confirms that learner's prior-knowledge predicts achievement in mathematics. However, the studies fail to comprehensively assess how learner's individualized prior-knowledge inform learning experiences that respond to mathematics achievement. This study therefore assesses the effect of individualized prior-knowledge in the context of IBL on mathematics achievement scores of learners in STEM-integrated secondary schools in Kenya.

RESEARCH METHODOLOGY

A descriptive survey was used as the design for the study using mixed methods. The form three class was purposely selected because it is approaching the end of secondary education and the achievement levels being assessed generally reflect learning outcomes. Data collection tools entailed; Lesson Observation Guide (LOG) and Learner's Participation Questionnaire (LPQ).

LOG was used to track how learner's prior-knowledge was actively assessed during the lesson and ideas used to develop the new concept. The LPQ was administered after the lesson to assess self-reported information on involvement of learners in sharing prior-knowledge during mathematics lessons. The tool also collected individual learner's KCPE 2019 mathematics mean scores, form one and form two mathematics mean score for years 2020 and 2021 respectively to assess progressive achievement. KCPE is a national assessment administered by the Kenya National Examination Council (KNEC) at the end of primary school grade eight to measure learning achievement.

Individualized prior-knowledge was the independent variable and mathematics achievement scores was the dependent variable. Individualized prior-knowledge construct was measured using the learner's KCPE score, participation questionnaire and the lesson observation guide to enable triangulation. Mathematics achievement was measured using learner's annual scores for two consecutive years in form one and two. Learners responded to six items that evaluated self-report on prior-knowledge activities.

Learners were asked to indicate the KCPE score, form one and form two mean scores and state how much they agree with the perception statements using the 5-point Likert-scale by selecting one out of five ordinal response options from 1 = Strongly disagree to 5 = Strongly agree. Higher values indicate higher level of focus on the prior-knowledge construct. The lesson observation guide included five items that assessed prior-knowledge construct using the five-point Likert-scale from 1 = Strongly disagree to 5 = Strongly agree.

The thirty-three (33) item measures of learner's participation in the inquiry-based approach in mathematics included six negative statements. Thus scores for the six items were reversed to eliminate errors of consistency in the interpretation of the responses. Reversing the scale entailed replacing 5 with 1, 4 with 2, 3 remained, 2 with 4 and 1 with 5. Missing data points were replaced using the Series Mean Method to ensure that the full dataset of 106 learners was available for computation.

The reliability of learner's participation questionnaire was measured using the Cronbach's Alpha which yielded a value of 0.858. This value indicates that the tool was reliable (Orodho, et. Al, 2016). Exploratory Factor Analysis (EFA) was used to determine construct validity of pilot data from the learner questionnaire on a Likert Participation Scale (Annum, 2017). The 33 item measures of learner participation in IBL were subjected to the Principal Component Analysis (PCA) method to determine the latent variables that determine variations in the data. Six factors focusing on prior-knowledge activities were found to be the main determinants of variation accounting cumulatively 44.5% of variation. The six items assessing prior-knowledge activities from Exploratory Factor Analysis (EFA) were aligned with individualized prior-knowledge construct. Notably component 1 which sought to determine learner's individualized prior-knowledge explained 20% of the variance (**Table 1**). The total variance explained was 67.8% thereby revealing satisfactory reliability and construct validity of the learner participation instrument.

Table 1: Total Variance Explained – Learner Participation

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.705	20.319	20.319	6.705	20.319	**20.319**
2	2.252	6.825	27.144	2.252	6.825	27.144
3	2.131	6.457	33.602	2.131	6.457	33.602
4	1.947	5.899	39.501	1.947	5.899	39.501
5	1.646	4.988	44.488	1.646	4.988	**44.488**
6	1.550	4.697	49.185	1.550	4.697	49.185
7	1.411	4.276	53.461	1.411	4.276	53.461
8	1.306	3.958	57.419	1.306	3.958	57.419
9	1.255	3.803	61.222	1.255	3.803	61.222
10	1.155	3.501	64.723	1.155	3.501	64.723
11	1.026	3.108	67.831	1.026	3.108	**67.831**
Extraction Method: Principal Component Analysis.						

RESULTS AND DISCUSSION

The findings and discussions are guided by the study objective on the effect of individualized prior-knowledge in the context of IBL on mathematics achievement scores of learners. Individualized prior-knowledge was analyzed using the learner's

KCPE score, learner participation and lesson observation ratings to enable triangulation. The learner participation questionnaire collected individual learner's KCPE mathematics score for 2019, annual secondary mathematics score at form one and two. Six perception statements, each expressing learner' participation through which individual prior-knowledge are manifest was analyzed using learner's ratings on the five point Likert-scale by selecting one out of the five ordinal response options.

Individualized prior-knowledge measured using learner's KCPE score, revealed strong, positive and significant correlation with mathematics achievement scores for 2020 and 2021 at p=0.035 and p=0.019 respectively (Table 2). The analysis showed that learner's achievement in mathematics scores in form one and two was significantly associated with KCPE mathematics scores respectively. The KCPE mathematics scores as prior-knowledge significantly predicted mathematics achievement scores for years 2020 and 2021 at p=0.035 and at p=0.019 (Table 3) respectively. The finding confirms that learner's prior test scores has positive effect on achievement because test scores determined extent of learner's understanding of concepts (Gnagey & Lavertu, 2016).

Table 2: Correlation Between KCPE 2019 and Math Scores in 2020 and 2021

		Mat_MS_KCPE_2019	**Mat_MS_2020**	**Mat_MS_2021**
Mat_MS_KCPE_2019	Pearson Correlation	1	.442*	.531*
	Sig. (2-tailed)		.035	.019
	N	42	23	19
Mat_MS_2020	Pearson Correlation	.442*	1	.787**
	Sig. (2-tailed)	.035		.000
	N	23	49	44
Mat_MS_2021	Pearson Correlation	.531*	.787**	1
	Sig. (2-tailed)	.019	.000	
	N	19	44	44

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Regression of MS_KCPE_2019 Against MS_2020

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	31.894	14.426		2.211	.038
	MS_KCPE_2019	.450	.199	.442	2.257	.035

a. Dependent Variable: Mat_MS_2020

Coefficients[b] **KCPE_2019 Against Math scores 2021**

model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	sig
2	(Constant)	16.598	17.138		.968	.346
	KCPE_2019	.617	.239	.531	2.582	.019

b. Dependent Variable: MS_2021

Participation Score and Mathematics Achievement

The learner's participation score had no significant effect on the mathematics achievement score at 2020 with $p>.05$ (Table 4). This finding is attributed to the fact that learners in year one were still getting accustomed with learning strategies in secondary education. However, one year later the learner participation score significantly predicted mathematics achievement at 2021 at $p<.05$ **(**Table 4). The finding is in agreement with the effect of learner active participation using strategies such as TPS which resulted in improved mean achievement scores and knowledge retention (Lee et al., 2018).

Table 4: Regression of Participation Score Against Mat_MS_2020 and 2021

Coefficients[a]						
Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	48.439	9.871		4.907	.000
	Participation Score	.213	.122	.246	1.738	.089
a. Dependent Variable: MS_2020						

Coefficients[b]						
Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	27.781	12.270		2.264	.029
	Participation Score	.423	.153	.392	2.761	.009
b. Dependent Variable: MS_2021						

Further regression analysis using the prior-knowledge score computed by summation of the rating on the six items and expressing it as a percentage. The score was regressed against mathematics achievement scores at 2020 and 2021 to determine predictor' significance. The prior-knowledge score was not a significant predictor of the mathematics achievement score at 2020 at p=0.46 (Table 5**)** which was year one of secondary education, but was a significant predictor of mathematics achievement in year two 2021 at p=0.058 **(**Table 5). The findings are in line with what other studies have documented on the effect of the type of prior-knowledge on learning achievement; indicating that procedural knowledge predicted the final grade while declarative knowledge did not predict final grades (Hailikari et al., 2007).

Table 5: Regression of Learner's Prior-Knowledge Score Against MS_2020 and MS_2021

Coefficients[a]						
Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	59.773	7.751		7.711	.000
	Participation Score	.072	.096	.108	.744	.460
a. Dependent Variable: MS_2020						

coefficients[b]						
Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	42.535	9.824		4.330	.000
	Participation Score	.239	.123	.288	1.946	.058
b. Dependent Variable: MS_2021						

Prior-Knowledge Assessment and Mathematics Achievement

Individualized prior-knowledge mean value based on lesson observation ratings was computed by averaging the ratings and summarized general observations into thematic constructs. The findings revealed insufficient assessment of learner's individualized prior-knowledge during lessons. The stimulation of prior-knowledge was examined using five strategies namely; stated pre-requisite knowledge, individual idea assessed, idea clarified using pair, group or whole class discussions, justified to raise curiosity and connections to new concept established. Therefore, the study analyzed the extent to which lessons applied the listed strategies to stimulate learner's individual prior-knowledge.

The analysis revealed that lesson planning stated pre-requisite knowledge as a strategy to stimulate prior-knowledge. Secondly, individual idea assessment strategy was employed through posing of questions. It was however evident that whole group questioning which is an important feature in IBL at the onset or during lesson, sampled some learner' responses while the rest confirmed the response through chorus feedback. This is contrary to findings of other studies on how pair work significantly influences learner active participation resulting in improved mean achievement scores and knowledge retention (Lee et al., 2018). Thus, determination of individual understanding of expected feedback on respective prior-knowledge was considered insufficient. Idea clarification using pair, group or class discussions strategy was insufficiently utilized to stimulate individual learner's prior-knowledge in mathematics. Yet, group discussions in inquiry-based learning has been found to enhance individual learner's understanding of science concepts and significantly influences understanding and reasoning (Warfa et al., 2018). Learners worked individually with some occasionally invited to demonstrate solutions on the white-board. Sampled learner feedback was accepted through chorus feedback, implying that the questions were either closed seeking a specific response or inability to consider divergent ideas of learners.

Learner's individual prior-understanding of key terms and demonstrations by some learners were clarified to raise curiosity and connections to the new concept through whole class discussions. This is because, planned individualized tasks that capitalize on individual prior-knowledge helps learners make sense of mathematics concepts, (Ernst et al., 2017). IBL is founded on the constructivist theory of learning that emphasizes the process of active learner' involvement in cognitive processes in order to construct understanding of mathematics concepts (Lister, 2015). IBL lessons motivated development of individual explanations based on prior-knowledge to resolve perceived knowledge gaps. Learner exploration and explanation of mathematical concepts was evident in some lessons which confirms what other studies have documented.

The emphasis for learners to explore before explanation in IBL further helps learners to make sense of mathematics concepts based on prior-knowledge (Ecke & von Renesse, 2017). Further scrutiny revealed that mathematics lessons were practicing confirmatory inquiry level where a question, method and solution plan were given to learners. Learners were required to use the examples to do similar problems with limited opportunities to clarify individual prior-knowledge for the context. Few lessons practiced structured inquiry level where a question and method were given and learners required to explore mathematics tasks to generate theorems. Inability to implement other levels of inquiry in mathematics could be explained on the basis of the complexity of implementing this levels and hence the popularity of confirmatory inquiry practice.

CONCLUSIONS AND RECOMMENDATIONS

The study aimed at investigating the effect of individualized prior-knowledge in the context of IBL on mathematics achievement scores of learners in STEM-integrated secondary schools in Kenya. Individualized prior-knowledge was measured using the learner's KCPE score, learner' participation and summary of observed prior-knowledge construct during lessons while mathematics achievement was gauged in terms of annual test scores.

The intention of this study was to generate findings that influence practice interventions focused on enhancing training and motivation of teachers to position learner's individualized prior-knowledge in lesson discourse as an important predictor of mathematics achievement. Furthermore, the purpose of the study was to inform policy deliberations at national, county and schools to prioritize resources for sensitizing educators and training teachers. In addition, the findings are aimed at motivating further research on individualized prior-knowledge as a predictor of mathematics achievement.

The descriptive survey with quantitative and qualitative approaches was applied. Primary data was collected using two tools namely; self-reported learner participation questionnaire and researcher-administered observation guide. Data was collected in October 2022 from 106 form three learners and observing six mathematics lessons taught by teachers trained on inquiry-based learning approach under the STEM-integrated secondary school program. Quantitative and qualitative techniques were employed to analyze data. Quantitative data analysis techniques entailed correlation and linear regression. Qualitative information sourced using lesson observation guide analyzed thematically revealed the extent to which learner's prior-knowledge was assessed to support meaningful learning and achievement in mathematics.

In conclusion, learner's prior-knowledge in the context of inquiry-based learning has significant effect on achievement in mathematics. Individualized prior-knowledge measured using learner's KCPE score, revealed strong, positive and significant correlation with mathematics achievement scores for two subsequent years. Learner's achievement in mathematics scores in form one and two was significantly associated with KCPE mathematics scores respectively. The KCPE mathematics scores as prior-knowledge significantly predicted mathematics achievement scores for the two subsequent years. This finding is in line with other studies on learner's prior test scores determining the extent of learner's understanding of concepts and hence positive effect on achievement (Gnagey & Lavertu, 2016).

The learner's participation score had no significant effect on the mathematics achievement score after one year of secondary education. This is attributed to the fact that learners in year one were still getting accustomed to learning strategies in secondary education. However, one year later the learner participation score significantly predicted mathematics achievement. The finding is in agreement with the effect of learner active participation using strategies such as TPS which resulted in improved mean achievement scores and knowledge retention (Lee et al., 2018).

The prior-knowledge score was not a significant predictor of the learner's mathematics achievement score in year one of secondary education, but was a significant predictor of mathematics achievement in year two. The findings are in line with what other studies have documented on the effect of the type of prior-knowledge on learning achievement; indicating that procedural knowledge predicted the final grade while declarative knowledge did not predict final grades (Hailikari et al., 2007).

Whereas lesson planning stated pre-requisite knowledge as a stimulation of prior-knowledge, the study showed insufficient assessment of individual learners. Question and Answer (Q&A) method was used to assess prior-knowledge and evidently, this strategy poses questions to the whole class which is an important step in IBL, but fails to capture individualized idea because real-time verbal responses are expected from learners say in a class of sixty. The implication is, lesson progresses with a few sampled responses. Inability to employ a variety of strategies to assess individualized prior-knowledge was evident because Q&A strategy was the most popularly. Idea clarification using pair, group or class discussions strategies was inadequately utilized to stimulate individual learner's prior-knowledge in mathematics. Pair work has been shown to significantly influence learner active participation which resulted in improved mean achievement scores and knowledge retention (Lee et al., 2018). Learners worked individually and some were occasionally invited to demonstrate solutions on the white-board. It is important to note that group discussions in inquiry-based learning enhance individual learner's understanding of concepts and significantly influences understanding and reasoning (Warfa et al., 2018). Inadequate opportunities were provided to compare responses on individualized ideas which is symptom of either closed questions seeking a specific response or inability to assess and harmonize divergent ideas.

Learner's individual prior-understanding of key terms and demonstrations were clarified to raise curiosity and connections to the new concept through whole class discussions using responses from some learners. This is because, planned individualized tasks that capitalize on individual prior-knowledge helps learners make sense of mathematics concepts, (Ernst et al., 2017). IBL lessons motivated development of individual explanations based on prior-knowledge to resolve perceived knowledge gaps. Learner exploration and explanation of mathematical concepts was evident in some lessons which confirms what other studies have documented. The findings inspired the question of which level of inquiry were the observed lessons functioning and why. Observed lessons practiced confirmatory inquiry level because a question, method and solution plan were given and then learners used worked out examples to do similar problems. Inability to implement other inquiry levels is attributed to the complexity of practicing structured, guided and open.

In conclusion, learner's individualized prior knowledge, significantly predicts mathematics mean score. Capturing learner's individualized prior-knowledge in the context of IBL lessons influences mastery of concepts and hence performance in mathematics scores. Mathematics educators need to continuously assess individual learner's prior-knowledge to design IBL learning experiences that support mastery and achievement. Policy recommendations on mathematics inquiry need to enhance prioritization of resources for sensitizing educators and training teachers on the role of individualized prior-knowledge as a predictor of mathematics achievement.

REFERENCES

1. Artigue, M., & Baptist, P. (2012). *Inquiry in Mathematics Education*. 16.
2. Artigue, M., & Blomhøj, M. (2013). Conceptualizing inquiry-based education in mathematics. *ZDM*, *45*(6), 797–810. https://doi.org/10.1007/s11858-013-0506-6
3. Bunterm, T., Lee, K., Ng Lan Kong, J., Srikoon, S., Vangpoomyai, P., Rattanavongsa, J., & Rachahoon, G. (2014). Do Different Levels of Inquiry Lead to Different Learning Outcomes? A comparison between guided and structured inquiry. *International Journal of Science Education*, *36*(12), 1937–1959. https://doi.org/10.1080/09500693.2014.886347
4. Dorier, J.-L., & Maass, K. (2020). Inquiry-Based Mathematics Education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 384–388). Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_176
5. Ecke, V., & von Renesse, C. (2017). Using Inquiry to Teach Mathematics in Secondary and Post-Secondary Education. In G. Kaiser (Ed.), *Proceedings of the 13th International Congress on Mathematical Education* (pp. 755–756). Springer International Publishing. https://doi.org/10.1007/978-3-319-62597-3_139
6. Ernst, D. C., Hodge, A., & Yoshinobu, S. (2017). What Is Inquiry-Based Learning? *Notices of the American Mathematical Society*, *64*(06), 570–574. https://doi.org/10.1090/noti1536
7. Gnagey, J., & Lavertu, S. (2016). The Impact of Inclusive STEM High Schools on Student Achievement. *AERA Open*, *2*(2), 233285841665087. https://doi.org/10.1177/2332858416650870
8. Hailikari, T., Nevgi, A., & Lindblom-Ylänne, S. (2007). Exploring Alternative Ways Of Assessing Prior Knowledge, Its Components And Their Relation To Student Achievement: A Mathematics Based Case STUDY. *Studies in Educational Evaluation*, *33*(3–4), 320–337. https://doi.org/10.1016/j.stueduc.2007.07.007
9. Kandil, S., & Işıksal-Bostan, M. (2019). Effect of inquiry-based instruction enriched with origami activities on achievement, and self-efficacy in geometry. *International Journal of Mathematical Education in Science and Technology*, *50*(4), 557–576.

https://doi.org/10.1080/0020739X.2018.1527407

10. Lee, C., Li, H.-C., & Shahrill, M. (2018). Utilising the Think-Pair-Share Technique in the Learning of Probability. *International Journal on Emerging Mathematics Education*, *2*(1), 49. https://doi.org/10.12928/ijeme.v2i1.8218
11. Lister, C. (2015, February 15). *Constructivism: The Foundation of Inquiry Learning*. Unlearn to Learn. https://christopherlister.ca/tiegrad-2/constructivism-the-foundation-of-inquiry-learning/
12. Marshall JC, Smart JB, Alston DM. (2017). Inquiry-based instruction: a possible solution to improving student learning of both science Concepts and scientific practices. Int J Sci
Math Educ.;15(5):777–796.
13. Morgan, H. (2021). Howard Gardner's Multiple Intelligences Theory And His Ideas On Promoting Creativity. *London, UK: KIE Publications*, *In F. Reisman (Ed.), Celebrating Giants and Trailblazers: A-Z of Who's Who in Creativity Research and Related Fields*, 124–141.
14. Mueni, C. N., Rugano, P., Mungai, J. N., & Muriithi, C. G. (2023). *Inquiry-based learning and students' self-efficacy in Chemistry among secondary schools in Kenya*.
15. Rayner, V., Benard, R. M., & Osana, H. P. (2013, April). *(PDF) A Meta-Analysis of Transfer of Learning in Mathematics with a Focus on Teaching Interventions Professor of Education*. https://www.researchgate.net/publication/319470004_A_Meta-Analysis_of_Transfer_of_Learning_in_Mathematics_with_a_Focus_on_Teaching_Interventions_Professor_of_Education
16. Republic of Kenya (RoP, 2017). Basic Education Curriculum Framework. Kenya Institute of Curriculum Development. https://kicd.ac.ke/wp-content/uploads/2017/10/Curriculumframework.pdf
17. Warfa, A.-R. M., Nyachwaya, J., & Roehrig, G. (2018). The influences of group dialog on individual student understanding of science concepts. *International Journal of STEM Education*, *5*(1), 46. https://doi.org/10.1186/s40594-018-0142-3