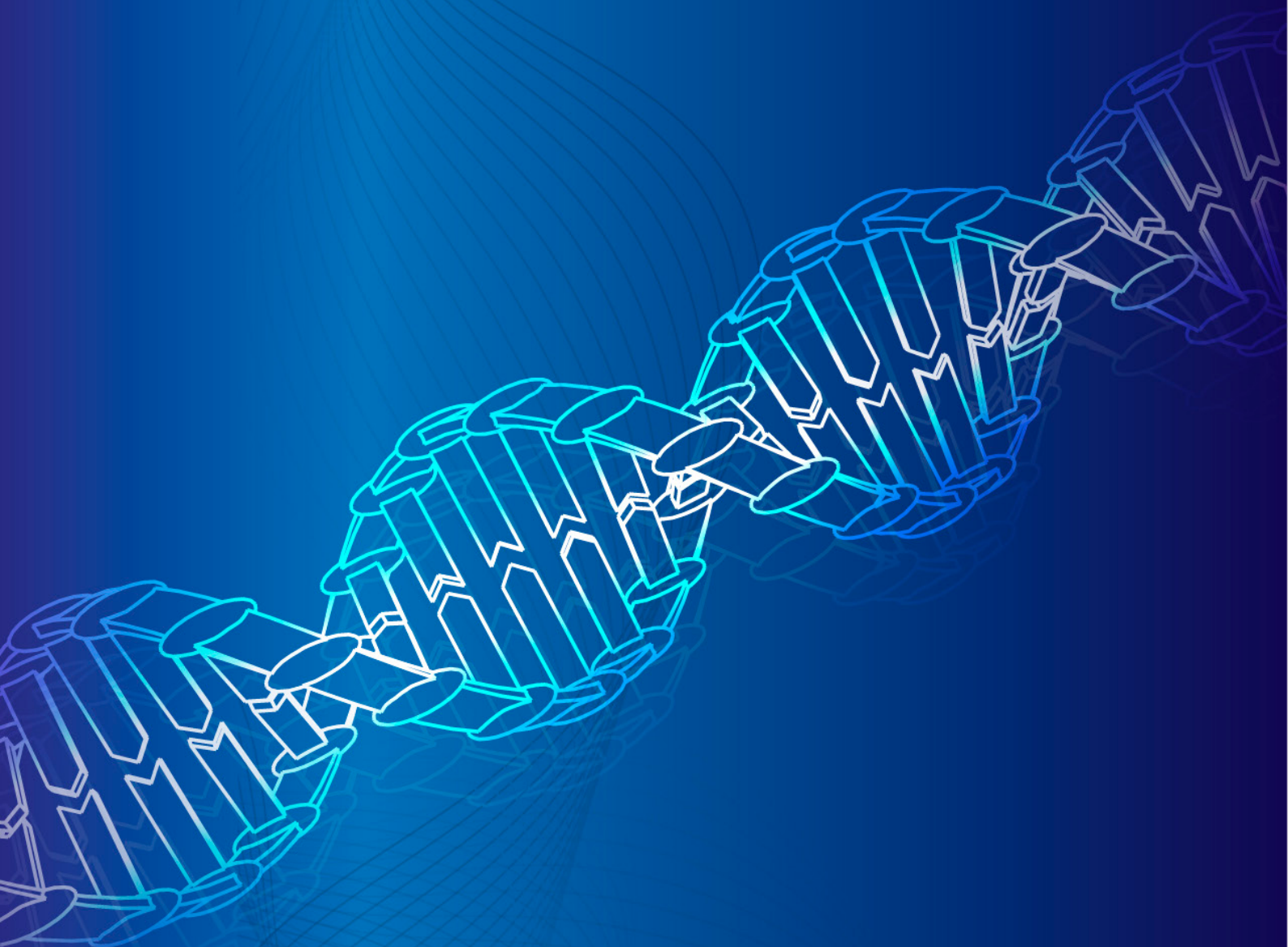




AMERICAN JOURNAL OF LIFE SCIENCE AND INNOVATION (AJLSI)

ISSN: 2833-1397 (ONLINE)

VOLUME 2 ISSUE 2 (2023)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Exploring the Global Pupil's Academic Performance in Linear Programming: A Glimpse on Literature Review

Mwambazi Chrispine Mulenga^{1*}, Mubanga Lombe², Francis Simui³

Article Information

Received: June 20, 2023

Accepted: August 17, 2023

Published: August 29, 2023

Keywords

*Curriculum Development
Centre, Emergence, Secondary
School, Continuous Professional
Development (CPD), Linear
Programming, Academic
Performance*

ABSTRACT

The main objective of this essay was to conduct an exhaustive literature review of the pupil's performance in linear programming. The study sample had 15 participants comprising 8 females and 7 males purposively sampled. The study concerning students' lived experiences of their academic success in linear programming was conducted using a hermeneutics phenomenology design. The study was qualitative as the details were descriptive, led by the specified methodology, and used qualitative research methodologies and procedures. This is a result of its stringent compliance standards for a variety of processes, including sampling techniques and data analysis methodologies (Mulenga, 2015). The intent was to describe the pupil's academic performance, explore pupils' linear programming-related disablers, and explore techniques for enhancing pupils' academic performance. The study was only carried out for six months. In light of this, it has been noted that the performance of pupils in linear programming is subpar as a result of a variety of complications, including lack of teaching and learning resources, incompetent teachers, pedagogy they use, pupils' attitude, mathematical language, time and the usage of subpar textbooks, among others. As a result, the existing difficulties have even led to pupils' low morale, which is prevalent worldwide, especially in developing nations. In order to address the issue of the topic being taught by incompetent teachers, it is advised that the government train and recruit qualified and competent mathematics teachers to teach the subject at senior secondary. Furthermore, additional time should be allotted to the challenging topics through collaboration between the MoGE and the Curriculum Development Centre (CDC). In order to support pedagogies among mathematics teachers, it is also advised that the MoGE strengthen Continuous Professional Development (CPD) initiatives in schools. Besides, the MoGE should receive more funding in order to purchase instructional materials for different schools across the nation. Teachers of mathematics are commended to use a variety of approaches, tactics, and strategies in order to enhance how they present the lesson they are teaching.

INTRODUCTION

The literature review in this article was based on the academic performance of pupils learning linear programming, disablers leading to such performance, and mitigation to attain better results. The research design was based on a hermeneutic phenomenological study of lived experiences of former grade twelve pupils in mathematics, specifically linear programming. In using the hermeneutic approach, researchers accept the difficulty of bracketing personal viewpoints as advanced through the transcendental phenomenology of Edmund Husserl (Simui, (2018). The researchers' decision to focus on grade twelve students' performance in linear programming questions and related questions was justified based on the Examination Council of Zambia's examination analysis report from 2015 to 2016 question by question performance analysis in mathematics at the national level (ECZ 2015, ECZ 2016).

It is evidenced that pupils hardly perform well in linear programming and related problems during national examinations (ECZ, 2014, 2015, 2016). According to the Examination Council of Zambia's general performance reports, it has been highlighted that linear programming was one of the topics in which learners have continued

to underperform during examinations at the ordinary mathematics level (ECZ, 2012-2017).

Significance of the Study

This study may be pertinent to those who create educational policy, especially those in the Ministry of General Education, subsequently it may help them implement strategies to lessen the challenges that pupils face when learning linear programming and to raise pupils' academic achievement. Furthermore, it is anticipated that this work will help teachers of mathematics better understand the challenges pupils face and develop strategies that will enhance their ability to teach. The review may also be pertinent to other scholars who wish to carry out additional studies in the area of linear programming. Also, it will advance the comprehension of linear programming.

LITERATURE REVIEW

Emergence of Linear Programming

According to Luneta (2022), the history of linear programming can be traced back to George Dantzig who developed it in 1947. He was studying proposed training and logistics for the United States military

¹ Munkuye Secondary School, Nkeyema, Zambia

² Institute of Distance Education, University of Zambia, Lusaka, Zambia

* Corresponding author's e-mail: mwambazicm@gmail.com

training program, as a mathematical adviser to the US Air Force Controller in the Pentagon. His colleagues at The Pentagon, Hitchcock, and Wood, asked him to find a method that would rapidly compute a time-staged operation, training, and logistical supply program.

Dantzig was motivated by the work of Leontief, who developed the simplex method for tackling linear programming problems and offered a sizable but straightforward matrix structure known as the “inter-industry input-output model” of the American Economy (Evans, J.R. 2020). In the model, there was a one-to-one correspondence between the production processes and the items being produced by these processes. According to the study by Sun (2016), Dantzig also used ideas from a paper by UNEB (2020) on game theory together with his ideas on steady economic growth to formulate a highly dynamic model that could change over time. He realised that The Air Force needed a model with alternate activities which had to be computable; hence, he invented the simplex method. The simplex method can be described as dynamic linear programming with a staircase matrix structure. By repeatedly shifting the vertex of the feasible region set to a nearby vertex with a lower, the approach creates a series of feasible iterations. If a better option cannot be found, the present optimal termination will take place. A realistic planning tool for huge complex systems is the simplex method (Boucher, C., 2023).

Pupil's Academic Performance in Linear Programming

Low academic performance of pupils worldwide in linear programming is a major concern. A number of studies on the Pupil in secondary school have been conducted including European countries, where pupils are very successful academically (OECD. PISA, 2018). Mainly, the Pupil's Academic Performance has been greatly affected by the size and location of the school, infrastructure, and enrolment rates. Each pupil's academic success is said to be greatly influenced by the availability of resources as well as the provision of teaching and learning aids. The aforementioned problems have a negative impact on pupils' academic progress in developing countries like Zambia.

Pupil Comprehension Experiences with Linear Programming

The Pupil Comprehension Experiences with Linear Programming at various secondary school levels, as well as contexts, are worrying. Two levels with varying contexts are considered namely: Developed and Sub-Saharan Africa contexts for easy comparative analysis of pupils in the current review. To this effect, this segment provides a context in which the current study is located as a way to contribute to the discourse on the performance of students in linear programming progressions at the secondary level.

The Meaning of Linear Programming

According to Nakhanu (2015), linear programming is a

mathematical technique for finding optimal solutions to problems that can be expressed using linear equations and inequalities. The term “linear programming” has the words programming and linear in it. The word “linear” describes a straight line that arises from the conditions between an independent variable (x) and a dependent variable (y). Programming is used to describe the methodical decision-making process in this manner. The mathematical equations for the relationships are $y = ax + b$, where a and b are constants.

Applied mathematics (operational research) includes linear programming, where the mathematical modelling is done using linear equations or linear inequalities, which includes designing programs to solve various daily life problems (Idris, Sulfiaty, 2015).

Meanwhile, according to Zhe Bao, *et al.*, (2020), linear programming is a program that can be applied to solve the optimization program.

The objective function and constraint equations are deterministic, and the Simplex approach can only be used to solve situations where there is no uncertainty in the variables or coefficients (Mohammed, A.R. and Kassem, S.S. 2020). Industries, including business, economics, telecommunications, manufacturing, transportation, agriculture, and the military, have adopted linear programming. In a real-world problem, it can be represented accurately by the mathematical linear equations, the method that can help to find the best solution to the problem.

Global Performance of Pupils in Linear Programming

There are many factors that contribute to the good or poor performance of novices in linear programming. The poor performance is due to teachers not being interested in teaching on topics that are contentious like linear programming, teachers' incapacity to provide students with the support they require, to use different teaching methods during linear programming lessons, and substandard instructional materials coupled with time allocated. There is a belief by some teachers of mathematics that linear programming could not be taught at the beginning of learning and within the timetabled time. The importance of promoting students' preparation for learning activities, however, makes this the wrong move (Puteri, 2018). Thus, the teaching of linear programming requires proper planning to ensure proper time management. In doing so, the pupils will have strong motivation and encouragement to absorb learning, so that it can attract pupils' attention (Ahn, 2014). Similarly, the study conducted by (PISA, (2018), examined the pupil and teachers views on linear programming, pupils' linear programming abilities were lacking as pupils were being taught in haste without taking into consideration the slow- learners. Additionally, when teaching the topic of linear programming, secondary school teachers paid little attention to it due to limitations in terms of pedagogical content knowledge, consequently leading to poor performance.

This collaborates well with the study by Lampert (2010), who asserted that a poor result in linear programming is resulting from the content provided to teachers throughout programs for teacher education, the methodologies used by some teachers, and the attitudes of the pupils and teachers towards the topic.

Equally, the study by Ball and McDiarmid (2010), shows that teachers struggle with linear programming because they are given content from colleges and other academic institutions that bear little or no similarity to real-world classroom situations.

In line with the aforementioned statement, the study by Stevenson, *et al.*, (2020) reveals that the primary concern of the American educational system today is that of raising the mathematics levels of its pupils. However, cross-national studies reveal that American school children routinely underperform Chinese, Japanese, and Korean pupils in mathematics because of discrepancies that become apparent due to cultural and familial influences. This means that culture contributes to pupils' poor academic performance in mathematics where linear programming is a part.

Further, the study by Fan, W.; Williams, C. (2018), revealed that parenting and family factors contribute to American students' poor performance than Asian pupils due to lack of motivation, curriculum differences, parental involvement, time use, and pupils' attitudes. Particularly, traditional Chinese views of teaching and parenting contribute to pupils' academic success (Ho, 1994). Pupils from homes whose parents cannot afford to support their children tend to do bad at school. Pupils who get adequate learning resources and other essential requirements from parents are motivated. Failure to which pupil Performance who are demotivated will always perform poorly. The study in Indonesia by Kusmaryano (2014), revealed that pupils perform poorly as they are expected to memorise the content without fully comprehending the concept thereby failing to use it in practical situations. This revelation collaborated with Khafidah, W., *et al.*, (2020) who postulated that the teacher-centred method compelled pupils to memorise the concept without fully understanding it. This was due to the failure of the teacher to come up with activities that promote critical thinking among pupils, hence resorting to memorization of material presented by the teacher.

This is consistent with a study by Lasco and Raganas (2016), who discovered that pupil interactions in the classroom, teaching methods, and resources all had an impact on pupils' performance and ability to learn linear programming. It has been proven that getting pupils involved in collaborative efforts can help them develop their mathematics abilities, which will help them do better in school.

In Indonesia, the study by Kumar & Vakkil, (2020), argues that good quality education is needed to achieve curriculum goals. The Educational Curriculum System strives to show that pupils have mastered a set of skills that have been determined based on the unique qualities

and characteristics of the material from the disciplines that meet the Minimum Completeness. Pupils' successes can take the shape of abilities they acquire through teaching and learning activities. The other studies in Indonesia by Suyitno, (2015) using Newman procedures to analyse errors pupils make in linear programming reveal that pupils make mistakes when solving mathematical problems due to a lack of reading skills, lack of understanding of questions, transformation, and process skills. The learning process depends on pupils' understanding and mastery of the material.

A barrier that may prevent a pupil from performing better is when they can read the question but cannot understand the statements included inside. Due to their incapacity to understand mathematical concepts and develop innovative perspectives, pupils do badly academically and provide wrong answers. Pupils make transformation errors. Transformation errors occur when pupils are unable to identify the pertinent mathematical operations. Lack of comprehension of some concepts in linear programming contributes to a lacklustre academic record (Suyitno,2015).

This coincides with a study by Herold (2014) who proposed that processing skill errors happen when students are unable to do mathematical operations correctly due to erroneous mathematical calculations and are unable to apply problem-solving techniques. The inability to comprehend and explain mathematical concepts in writing, locate the points where two axes cross, or resolve various types of inequality are frequently to blame for students' poor results in linear programming. Similarly, a lack of pupils' ability to use mathematical language in linear programming affects pupils' academic performance. This claim is supported by a study by Sukoriyanto (2021) that looked at how pupils' use of mathematical language hinders their ability to comprehend the coordinates of the corner points thereby causing them to use the incorrect determinant objective functions, which automatically produces the wrong optimum value. The learning approach is a crucial factor that must be considered in the teaching and learning process because the learning approach is a means to realising teaching goals. The more thoroughly the learning objectives are realised and the educational goals are achieved, the better the learning approach chosen. Facts are frequently ignored in favour of knowledge and procedural learning (Olusegun S.,2015). By examining the facts, pupils truly gain a complete comprehension of the problem, assisting them in learning and achieving the learning objectives.

According to Amir, Z. (2015), the terms in mathematical language can be defined carefully, clearly, and accurately. The process of presenting mathematical concepts while developing concepts and understanding is known as mathematical communication. Abdullah (2018), did a similar study on the resources and teaching strategies utilised by teachers in Asia. The purpose of the research was to assess the efficacy of the study materials and teaching methods. It was discovered that teachers were

using ineffective teaching strategies and educational materials, which made it difficult for pupils to comprehend connected ideas and the core of linear programming. The study also discovered that students did not think highly of linear programming.

Mariano Luque, Sandra González-Gallardo, and Ana B. Ruiz's study (2019) used interval multi-objective linear programming to evaluate pupils in Finland and Spain. According to the study, the pupils' subpar academic performance was caused by the teachers' unstable methodological methods and the learning environment for the students (PISA, 2018). Pupils' academic success in linear programming was negatively impacted by inadequate time organisation, insufficient lesson planning, and ineffective teaching and learning strategies.

This claim was corroborated by Willis & Judy, (2010), whose study on guide for learning and to love mathematics: teaching methods, pupils' attitude and get results postulated that learners usually have a difficult perception of linear programming as a topic and this affects their performance. The study in the Netherlands by Phakeng, M. S., N. Planas, A. Bose, and E. Njurai. (2018), on teaching and learning mathematics in trilingual classrooms from three different continents in Mathematical discourse that breaks barriers and creates space for marginalised learners, revealed that pupil's academic performance was poor because pupils had a fear of mathematics.

This revelation was affirmed by Bell, S. *et al.*, (2016), in the Republic of Ireland, whose study revealed that pupil's poor academic performance was a result of many challenges pupils undergo such as social and mental. The study by Munawar (2014), examined how team teaching affected mathematical achievement among pupils in the eighth grade. The conceptual comprehension and procedural knowledge of pupils in algebra and geometry were the main areas of focus. Pupils struggled with graphing inequalities and had difficulties understanding the symbolic inequalities from the given word problems. They also misinterpreted the significance of the inequality markings. Pupils had trouble comprehending complex ideas, and the worst reading-level mistakes were indications of pupils' poor knowledge of mathematical language. Understanding concepts and procedural expertise is crucial for improving pupils' academic performance.

The academic success of pupils in linear programming is negatively impacted by their academic learning background. Early childhood education had a long-term beneficial impact on academic achievement. According to Cortázar (2015), in his study on the long-term impacts of public early childhood education on academic achievement in Chile. However, this effect differed based on parental socioeconomic status, with middle-low socioeconomic status children benefiting the most. A strong educational foundation enables pupils to develop lifelong abilities that preserve and promote early entry into the educational community, aid in academic success, and lessen the likelihood of academic failure.

A comparative study conducted in China by Liu *et al.*, (2015), on the predictors of mathematics achievement of migrant children in Chinese urban schools, concluded that among many variables, a strong education foundation has a strong impact on the mathematical achievement of migrant children in Chinese urban schools. On the other hand, the study by Capraro and Joffrion (2006), in Liouaeddine *et al.*, (2017) revealed difficulties students frequently encounter when solving equations, including a lack of a symbolic understanding of variables, no knowledge of the representation of equality, reliance on skills without conceptual understanding, and coefficients in an equation. Pupils must fill in this knowledge gap in order to do better in their academic work.

Developing Countries Pupils' Academic Progress in Linear Programming

Pupils in Developing Countries have consistently performed below average in linear programming. According to a study by Pongsakdi (2020), the methods teachers employ to increase pupils' knowledge have a substantial impact on how poorly pupils perform in linear programming. The review by UNEB (2016) revealed that mathematics has historically high failure rates, particularly in linear programming. The majority of pupils struggle to respond to this question as most of them struggle with this problem repeatedly; they frequently pick the wrong scale, forget to plot the inequalities they've constructed, name the axes improperly, neglect to specify integral solutions, and fail to maximise the viable region. Mathematics classes may also be impacted by the lack of mathematics teachers in elementary and secondary schools. Poor academic performance is a result of an unfavourable learning environment that isn't furnished with enough instructional materials to support the teaching-learning process (Abijo, 2014). This finding is consistent with research by Abdullah (2014), who claimed that the absence of an environment that is conducive to learning and furnished with sufficient educational resources to support the teaching-learning processes will result in ineffective teaching and learning, which will impair academic achievement.

Distance is yet another factor that affects academic success. Distance might emotionally impact academic success. Being physically apart from a partner can cause emotional distress and emotions of loneliness, grief, or anxiety. These emotional pressures might cause people to lose focus and get sidetracked from their academic goals.

Long-distance maintenance takes time and effort. It can be difficult to balance these duties with academic obligations, which puts pressure on time management abilities. If not handled properly, it could lead to less study time and poorer academic performance.

It could be challenging to concentrate on studies or assignments when the thoughts and heart are on the distance to be travelled. This may cause frustration and have a detrimental effect on academic success.

Social isolation is another consequence of distance.

Distance may limit social interactions and involvement in school activities. Having fewer social connections might negatively impact one's welfare in general and subtly impact academic performance.

It's important to keep in mind that long-distance travel frequently ends in hunger. Hunger is a factor that inhibits academic progress. This conclusion is consistent with Alordiah (2015), assertion that poor pupil performance is caused by a higher prevalence of hunger in rural Tanzania and Nigeria. Mhiliwa (2015), discovered that long walking distances, exhaustion, and hunger all had a detrimental effect on pupils' performance in school. This will lead to low performance from the pupils. In Morocco, the study by Liouaeddine *et al.*, (2017), quantified that, several empirical studies have shown that low academic performance is closely correlated with the home environment. These studies generally tend to measure the home environment in terms of Socioeconomic Status, which is influenced by the social class of the family, the level of parental education, and the material resources of the family. In agreement with this assertion Hair, *et al.*, (2015), examined the link between poverty and children's learning. The children from low-income households scored 4 to 7 points lower on standardised tests. Persistent low family income is associated with poorer attendance and low academic achievement in elementary school.

Zambian Perspective

The Zambian pupils' effectiveness in linear programming has fallen below expectations. According to the chief examiner report ECZ (2017), many pupils perform poorly because of poor answering techniques. This is due to pupils not understanding the question properly as most teachers had not acquired the appropriate competencies for linear programming. Consequently, pupils are affected and struggle to apply the concepts of linear programming to questions involving the creation and solution over time. This claim is supported by Koji Samuel's (2016), whose study was to ascertain the difficulties encountered when learning. The study's findings indicated that pupils perform poorly. These claims are strongly supported by the chief examiner's annual reports for the mathematics section, which were produced by the Examinations Council of Zambia (ECZ). It has been revealed that, despite admirable efforts, the issue has persisted. The teacher education curriculum has caused a decline in mathematics achievement. The study by Mbetwa (2016), emphasises that the mathematics teacher education curriculum too contributed to what the country is experiencing. The teacher's lack of expertise in the topic led to the pupil's low efficiency in linear programming. Some teachers lack the expertise necessary to cover all mathematics topics (MOE, 2018). They do omit some topics that seem to be particularly difficult for them to impart to the pupils. For instance, certain teachers may find it challenging to teach linear programming, and their only option is to omit it from the curriculum while deceiving pupils into believing that the topic is not covered or that it won't be on the test.

Disablers Affecting Academic Pupils Performance in Linear Programming

In their research, Mwambazi *et al.*, (2023) revealed what influences pupils' proficiency in linear programming globally. Long periods of time pupils had to spend travelling, dearth of excellent teaching and learning resources like textbooks. Ineffective teaching strategies used by certain teachers have a poor impact on the final examinations for linear programming. According to Idris and Sulfiaty's (2015) research, pupils have problems understanding the concept of linear programming. Pupils have trouble comprehending and appreciating the concept because of the prerequisite knowledge that must be learned, such as linear equations and linear inequalities. According to international research, American schoolchildren routinely do worse in maths than students in China, Japan, and Korea (Stevenson *et al.*, 2020). Cultural and familial variables have a significant influence on the discrepancies because they can be seen as early as kindergarten. Parenting and family-related topics came up once more. According to research, American children perform worse than Asian pupils across a range of domains, including curricular variances, parental involvement, time management, and teens' perceptions of their own comfort and competence in mathematics. The intellectual growth of those children is severely hampered by traditional Chinese parenting and teaching techniques (Ho, 1994). An earlier analysis of the literature found that students commonly have trouble solving linear programming issues because of their poor comprehension and lack of foundation knowledge. This poses a challenge and learning outcomes for the pupils. According to Skemp (1971), in order to properly study higher-order topics, pupils must have a thorough understanding of the relevant lower-order concepts. Munawar (2014) studied eighth-graders' mathematical abilities in Pakistan. The main areas of emphasis were students' conceptual knowledge and procedural proficiency in algebra and geometry. Pupils had difficulty graphing inequality and failed to infer symbolic inequality from supplied word problems, and they misinterpreted the use of inequality marks. Pupils struggled with wordy problems, and the worst reading-level errors were signs of the pupils' poor command of mathematical language. Conceptual understanding and procedural knowledge are essential. Another difficulty is presented by the educational environment in which pupils are studying linear programming. This assertion is in line with research from Moschkovich (2018), who conducted research in the UK and found that students should participate in mathematical classroom discourse and meaningful written exercises, talks, or interactions when engaging in mathematical activities, all of which can only occur in a supportive environment. These in-class activities help teachers gauge how well their students have mastered the subjects under discussion and decide whether additional help may be required. Students should actively and publicly participate.

This claim is supported by Changwe and Mulenga's (2018) findings, which show that most mathematics teachers lacked capabilities and expertise in linear programming. Similarly, it was discovered that the university did not offer a specific mathematics topic course for those pupils who intended to become teachers, indicating a lack of the mathematical proficiency required for teaching. The revelation was supported by Iheanachor's (2017) research in Lesotho on the effect of teachers' backgrounds, professional development, and teaching methods on pupils' mathematics achievement in Lesotho, demonstrating a positive correlation between pupil mathematics performance and teaching methods. The years of experience, and teaching methods of teachers were all associated with the mathematical proficiency of their pupils.

According to Adino (2015), whereas a positive attitude is strongly correlated with success, a negative attitude is considerably linked to failure in all activities. It's important to remember that when teaching and learning are interesting, entertaining, meaningful, and applicable, students are motivated to learn. As a result, they are eager, focused, attracted, and ready to absorb the information being offered.

NCDC (2018) also carried out research in Uganda, and pupils had unfavourable opinions of mathematics, particularly word problems. The eleventh graders in Uganda's lower secondary schools are exposed to linear programming (using a graphical method). Despite this, the curriculum's goal is to help them master linear programming. Pupils face a challenge because there isn't any teaching or learning resources available for linear programming, leaving them without any books to use for their studies. Mulenga and Kabombwe (2019) bolster the assertion that there aren't enough teaching and learning resources in Zambian schools. The current study's findings therefore agree with Mwanza and Silukhuni (2020), who found that low student performance in the classroom was a result of a variety of factors including a lack of suitable educational resources, large class numbers, unattractive classroom environments, and subpar desk quality. Poor arithmetic performance can be ascribed to a variety of factors, including teaching methods, student materials, problems with policy, and curricular changes. These factors collectively impact how effectively linear programming may be taught. Therefore, a lack of resources is the main cause of poor academic achievement.

When teaching linear programming, pedagogy is crucial. According to Lee, *et al.*, (2018), students' ability to learn linear programming is influenced by the teaching approach. The teaching approach can either make pupils understand the material or not. The secondary school students' conceptual understanding of algebraic expressions and associated concepts, and the pedagogy used, are essential to their ability to learn linear programming.

UNESCO's (2018) report, found that teachers of mathematics must also be proficient in grasping the topic's foundational ideas, concepts, and related abilities. This implies that teachers should understand how to

inspire pupils. The perceptions and beliefs pupils bring to class must be taken into consideration by teachers. Before introducing new mathematical concepts to the class, the teacher must build on the information that the students currently have. The students shouldn't be seen by the teacher as empty canvases ready to be filled with new knowledge.

The difficulty of word problems involving linear programming prevents pupils from understanding what is being taught. Pupils struggle to understand mathematical word problems, which impacts their procedural comprehension and competency. According to Pongsakdi *et al.*, (2019), this is brought on by the academic backgrounds, prior conceptual knowledge, and attitudes of the pupils toward mathematics. NCDC (2018) conducted a study in Uganda on the factors that predict s Learning Linear Programming word problems generally aims to improve students' problem-solving skills, application of prior algebraic conceptual knowledge, and comprehension of writing models from word problems, as well as from real-life problems. Despite the learning difficulties, the goal of the Linear Programming topic is to give students the necessary knowledge and abilities to complete advanced mathematics courses beyond the Uganda Certificate of Education's minimum mathematical proficiency (UCE).

The consistent reports (UNEB, 2020) on previous exams and candidates' work demonstrate that students' performance in mathematics, particularly at the distinction level, is not satisfactory. Previous examiners' reports, in particular, highlight students' subpar performance in word problems involving exams and also showed that many students had serious Linear Programming related deficiencies. The main difficulties that students encounter in Linear Programming are related to their creation of incorrect inequalities based on the given word problem in practical settings. Incorrect solutions can all result from incorrect models that were derived from the questions. As a result, these difficulties (and others) might make it difficult or impossible for students to build useful applications (Sudihartinih, E., 2019).

Furthermore, while some pupils manage to avoid other learners consistently show cognitive barriers when responding to questions on Linear Programming. Factors that explain pupils' weaknesses in learning Linear Programming and targeted interventions to address those weaknesses are conspicuously absent. UNEB (2020) reports a bad feeling about linear programming. However, a pupil's attitude may have a direct impact on how well they learn and perform. Mbugua *et al.*, (2012), showed that learner performance in mathematics, particularly in linear programming, was poor.

The study by Koji (2016) looked into the difficulties faced by pupils. It was revealed that Pupils lacked the prerequisite knowledge necessary as well as inappropriate teaching strategies and techniques, which are just a few of the issues that have been identified.

Another study by ECZ (2016) demonstrated that

understanding is necessary for learning linear programming. It uses mathematical symbols in its own vocabulary. During national exams, students had trouble completing the linear programming tasks that were required to develop a mathematical model. This is because mathematical models are made up of inequalities that are derived from word problems (Nkhata *et al.*, 2018). Therefore, the ability to extract meaning from the word problem in order to construct the intended linear inequality system is necessary for the precise formation of mathematical models. Nkhata *et al.*, (2018) stressed that learners “should pay special attention to the expressions especially which change the sense of the inequalities” because of this. Such words include “at least,” “at most,” “not less than,” and “no more than,” to name a few. The inability of learners to acquire the crucial comprehension skills for linear programming would mean that improving learners’ abilities would continue to be difficult. As a result, most Zambian students now consider mathematics to be a foreign topic that they merely need to master and pass in order to satisfy the criteria of the nation’s educational system (Sakayombo, 2018).

In Zambia, the study by Mulenga, M. C., Lombe, M., & Simui, F. (2023), revealed that linear programming at the senior level was poorly performed due to a variety of disablers due to the travel time required for pupils (distance), lack of quality tools like textbooks, inefficient teaching methods employed by some teachers (pedagogy), lack of parental support, pupils’ lack of prerequisite knowledge in linear programming (poor learning background), learning environment, pupils’ negative attitude, and lack of a school library. Further, most of the teachers who taught the component were not conversant with linear programming.

Strategies to Enhance Pupils’ Linear Programming Academic Performance

To help pupils do better in linear programming, teachers should use appropriate and efficient learning for conceptual and procedural understanding. González-Gallardo, Ruiz, and Luque (2021) claim that thorough lesson planning with the pupil in mind can enhance pupils’ academic achievement. It is commonly accepted that for any test, they must understand the concept, which incorporates a related number of concepts.

Academic success is frequently characterised by a thorough approach that enables pupils to quickly absorb subject matter, and the use of effective teaching methods that encourage pupils to feel happy, connected, and perform well in school. A pupil’s performance in school is influenced by how well the teacher gets along with the pupils teaching they are given. Teachers should motivate pupils and use appropriate teaching and learning tools in order to foster accurate learning and a disciplined environment in the school learning context (Kern, M.L.; Waters, L.E.; Adler, A.; White, M.A. 2015). Similarly, the OECD’s 2019 study on how to simultaneously optimise for the best level of pupil well-being found positive

emotions, motivation, a sense of belonging, and the teaching-learning environment elements that encourage pupils to perform well. This claim is consistent with a study by Ahdika, A. (2017), which stated that performance is enhanced by a supportive learning environment. A favourable learning environment increases the success of cognitive learning.

Learning happens naturally when pupils engage in the activities and gain experience rather than just lecture (Fletcher, J., 2018). Andriyani, Karim, and S. Fahmi (2020) postulated that using an approach that is student-driven to instruction would help students improve their ability to solve issues, learn new material, build new thought patterns, and adopt a positive outlook. A study by Aizikovitsh-Udi E. and Cheng D. (2015), recommended that students should develop higher-order cognitive skills, such as critical thinking, throughout the progression of their education in schools.

According to Kosarenko N. N. *et al.* (2016), the purpose of critical thinking is to actively work on understanding, applying, analysing, and synthesising (evaluating) knowledge by observing, gathering data, processing data by reasoning, reflecting, and expressing the results achieved. In light of this, Fitria, R., Hairun, (2020), affirmed that still another definition of critical thinking assesses fresh knowledge. If appropriately used, critical thinking abilities can aid pupils in enhancing their academic success in linear programming.

This is made obvious by the indicators utilised in problem solving, such as giving precise justifications, improving fundamental skills, coming to conclusions, offering further justifications, and developing means and tactics to reach findings (Paul, R., and Elder, 2012). Pradeep, M. D. & Aithal, S. (2015), when pupils are able to communicate their thoughts while solving a mathematical problem, academic achievement would only rise. Teachers should push slow learners to fulfil their maximum potential in comparison to their gifted counterparts for them to succeed academically even though they are slower than other pupils (Fitri R. M. *et al.*, 2019). This is largely ignored by teachers.

Since algebra provides an important basis while introducing algebraic topics to their pupils (Lee, Y., Capraro, R. M., & Capraro, M. M., 2018). However, Putranto S. and M. Marsigit (2018) argue that teachers should support sluggish students in developing their ability for critical thought by using the computational thinking method for students’ academic achievement. Pupils’ abilities can be enhanced through the Computational Thinking (CT) paradigm. The Computational Thinking (CT) method sharpens the minds of pupils to become more acclimated to thinking in a structured, analytical, and logical manner. The learning process using a computational thinking method has its own allure because it is founded on a concept that seeks to address the difficulties encountered so that they may be resolved quickly in a constrained amount of time and demand little resources, physical resources, and digital storage space (Painagoni K., 2018).

Therefore, according to Nixon, R. S., Toerien, R., & Luft, A. J. (2018), teachers must apply techniques and effective strategies to encourage pupil engagement and conceptual understanding. Based on the PISA (2018) dataset, this study focused on Spanish and Finnish pupils to examine the disparities in well-being that existed between these two populations. While Finland typically ranks in the top positions of international rankings evaluating pupils, Spanish pupils have shown low educational performances in comparison with pupils from other European countries (González *et al.*, 2021).

The research by Opolot-okurut (2010), looked at the links between attitudes and performance of Ugandan students. The study found a direct, significant, and favourable association between understanding mathematics and the adoption of an appropriate teaching strategy. Therefore, pupils should adopt an optimistic mindset to enhance their potential to acquire concepts of linear programming. Pupil's mindset may change, which may impact their mathematics performance.

The earlier empirical studies on how having the right mindset could improve student performance. Students should be motivated, excited, engaged in what they are studying, and enthusiastic about it (Mata, M., Monteiro, V., 2015). Additionally, this will serve as a lens for improving students' proficiency with both ordinary mathematics and word problems involving linear programming. Students' academic progress will be improved by adopting techniques to teach linear programming. According to Juilus and Pongsakdi (2020), teaching methods are more effective in making sure that students understand what is being taught. Furthermore, according to Abreh, M. K., Owusu, K. A., & Amedahe, F. K. (2018), teachers should select instructional strategies that can improve students' academic performance in all subjects taught in school, in both low and high grades. Dude, (2020), claims that using a clear and simple approach will help students learn more. Pupils' performance in linear programming will be enhanced by learning that has a contextual focus and uses local resources. The contextual materials are beneficial for both teaching and learning. According to Damopolii *et al.*, (2021), learning materials that have been updated using the Contextual Teaching and Learning approach improve student concept mastery. If used properly, they can boost pupils' academic performance.

The primary tenet strategy is the development of students' conceptual application skills. The argument is founded on constructivism theoretical paradigm, which contends that students should continuously reflect on previously learned knowledge (Smith and Johnson, 2018). Budiman *et al.*, (2020) reveal that Students' ability to think logically while learning can be maximised by using suitable methods. Despite having varying levels of motivation, students may read and comprehend text in a textbook well. The benefit paradigm is that students can investigate the phenomena in their immediate surroundings to strengthen their conceptual understanding. In applying Contextual Teaching and Learning model pupils appear active,

motivated to solve problems, and increase concept mastery throughout their learning processes, (Ekowati *et al.*, 2015). According to Martins *et al.*, (2018), a learning process in linear programming should enable the pupil to detect a real problem and turn it into a sequence of tasks that will finally be translated into a simple language. This assumption is consistent with their findings. According to Qian *et al.*, (2020), teachers should motivate the students to keep up their hard effort in order to lower the implicit complexity of linear programming. The teacher should also guide the pupils. Additionally, Dorn *et al.*, (2018) claim that even though teachers are facilitators, understanding the challenges of teaching programming can help them implement pedagogical strategies that benefit pupils during their learning process.

Significant results were presented by Gómez *et al.*, (2020) and Zhang *et al.*, (2018) to choose appropriate strategies using multi-criteria methods like Solutions in order to generate high-quality solutions. The TOPSIS technique considers the ideal and anti-ideal solution notions while choosing between different courses of action. The observation that a certain alternative is located halfway between the nearest farthest negative ideal solution serves as its basis. Prior to beginning a new session, teachers should go over the prior one. Before beginning to teach the most recent lesson, the previous lesson should be in order. This will aid the pupil in making connections to the prior lesson. According to research by Blum, Galbraith, Henn, and Niss (2017), it is important for teachers to start classes by connecting concepts to past knowledge, such as linear inequality, and to give students incentives to learn the benefits of or practical uses for linear programming. The teacher might, for instance, use the students' prior knowledge to explain a linear inequality of two variables before applying the innovative idea to linear programming. Students may find it simpler to comprehend the material and draw connections as a result. This will enhance pupils' intellectual comprehension, their cognitive, and emotional grasp of it. This is true because pupils' affective domains may have an immediate cognitive and psychomotor domain. How the students approach word problems that require linear programming, and how successfully they can respond to them will be greatly influenced.

According to Muis *et al.*, (2015), changes in students' attitudes and performance are greatly influenced by their epistemological views. Asempapa (2022) claims that teachers' educational techniques that consider the particular qualities of each pupil may result in a shift in the pupils' attitudes, thereby promoting pupils' active participation.

Nakhanu, Shikuku, and Wasike (2015) explored whether problem-based learning can improve and encourage the teaching of students in Kenya. This was an intervention measure for problem-based learning to enhance students' understanding. The focus was instead on the methods teachers employed, with a specific focus on whether they used the extreme point and origin tests to include a problem-based learning strategy. Problem-based learning

is the most effective strategy for raising student-centred educational strategies known as problem-based learning, where students acquire knowledge by addressing problems in real life. Gained is critical thinking domain knowledge. The objectives of problem-based learning (PBL) are to help pupils acquire adaptive information quickly. According to a study by Kenney (2020), teachers can successfully teach, tutor, and counsel pupils to overcome learning obstacles.

Through seminars and workshops, seasoned teachers may be permitted to impart their best by developing and fostering pupils' mathematical talents. Teachers should work together regardless of gender disparities, school locations, and concerns to help pupils set and achieve their goals while facing linear programming problems. When teaching linear programming teachers should ensure that the fundamental ideas are understood, and pupils must be able to respond appropriately. Tsamir and Almog (2015) looked at how students were affected by active learning and a heuristic approach to problem-solving. According to research (STEM), linear programming and inequalities are related and effective optimization techniques. Pupils, overcome their struggles with algebra and linear programming in particular and consequently increase their skills, it is imperative to adopt or modify successful learning methodologies. Particularly, students should be given a sufficient introduction to and training as they are essential for their comprehension of linear programming. Teachers should promote a constructive stance on teaching linear programming. This encourages a greater desire to understand it (Tumuti, 2015). The teacher should sufficiently include the class in the subject matter through the tactics used, as student engagement is crucial. For pupils to remain interested in learning about linear programming, they must devote an effort to the subject. Instead of treating them like passengers, treat them like active participants. This demands that the teacher possess strong linear programming skills. Teachers must have pedagogical expertise. Additionally essential are the teachers' continual, regular comments, and correction measures. Better academics is always the outcome of providing feedback to pupils and taking corrective measures. In order to catch up to other students, remedial work seeks to address students' weaknesses. Pupils that actively participate in class are produced via interactive teaching approaches. The effectiveness of project-based learning, group activities, and discovery methods has been established. Pupils perform better when humour-teaching approaches because humour makes a class interesting and pleasurable (Ngussa and Mbuta, 2017).

Pupils' academics will be boosted by the availability of instructional resources in schools, the decrease in overcrowded classrooms, as well as other additional factors. (Mulenga 2015). According to Tichapondwa (2017), another tactic that might improve pupils' academic success is team teaching. How well students learn or approach learning is greatly influenced by the teaching strategies employed by their teachers. This

implies that educators may apply a variety of cutting-edge instructional strategies to help address the learning challenges impeding pupils' academic advancement. One of these cutting-edge teaching techniques, among many academics, is team teaching.

Another powerful technique for raising pupils' interest is group discussion. Solehah *et al.*, (2021) claim that group discussion helps the other students who listened to the instruction to understand the subject. The activities that students engage in and how they develop their thinking are related. Because they receive more scientific information from different groups, pupils' thinking develops. The learning activities of pupils are improved and reading material is increased when they actively participate in group discussions. The knowledge pupils gain from having conversations with peers in groups encourages them to talk clearly and communicate effectively when sharing information and helps them remember things when asked (Sudiyanto *et al.*, 2020).

Strategies to Enhance Pupils' Linear Programming Academic Performance

Research on teachers' methods for a few secondary schools in the Monze region, Kaabo (2019) found that understanding the concepts and symbols used in linear programming depends on teachers' approaches used in secondary schools. In order to give essential contact with the concepts and symbols to improve their application in an interactive learning environment, attention should be applied to the teaching approaches that are created from the introduction to the finish of the lesson.

The study further established the constraining factors in effective teaching hinged on the intervening measures that were suggested to overcome the constraints. The constraining factors were; the region to be shaded for linear in the equation and linear programming was not consistent, less learner interaction with a variety of linear programming questions/situational statements, and getting in equations to form linear programming questions to enhance the understanding of terms and associated inequality symbols was inadequate.

Koji *et al.*, (2016), in their study in Mufulira District, stated that before pupils are exposed to equations, the teachers need to arm themselves with more adaptable teaching strategies. By creating a supportive learning environment for pupils, these alternative teaching methods aim at these diverse learners. Teaching objectives and learning outcomes are no longer the only considerations when it comes to how to teach. To accommodate pupils' varying abilities and help them excel in their studies, teachers are urged to adopt progressive teaching methods.

CONCLUSION

Linear programming is faced with many challenges as emerged from the literature reviewed. These difficulties have contributed to pupils' poor academic achievement, particularly in developing nations. The topic's objective might not be achieved if this situation continues. Therefore,

the Zambian government must work to mitigate the highlighted challenges not only to enhance the topic delivery but also to the pupil's academic performance.

RECOMMENDATIONS

The following are recommendations that can help improve performance:

1. Mathematics teachers should use the right resources and instructional methods for better comprehension of mathematics concepts.
2. There must be extensive practice i.e., teachers should assign enough homework to keep their students practising.
3. The Zambian Examinations Council to examine the mathematics curriculum and make it more approachable because the current syllabus is excessively loaded.
4. There should be a manageable number of pupils enrolled in class in order to give personalised education. Consequently, the official teacher-to-student ratio should be considered.
5. There should be enough textbooks and other teaching/learning resources available for students' academic endeavours.
6. To address the issue of incompetent teachers, it is advised that the government employ competent teachers of mathematics around the nation.
7. More time to be allocated to difficult topics like linear programming.
8. The pedagogies used by maths teachers should be improved, and school administrators should strengthen monitoring systems in schools.
9. Mathematical instructors should employ a range of techniques, tactics, and strategies in the way they present their subject matter.

Chapter Summary

The researcher reviewed pertinent literature to prevent repeating prior studies. It additionally enables the researcher to identify knowledge gaps in earlier studies. Additionally, the chapter covered the development of linear programming, progression, and students' performance on a worldwide level. It is sufficient to say that the study's literature evaluation established the importance of linear programming for any nation's development. Additionally, it has come to light that there are a variety of factors, such as lack of resources and ineffective mathematics teachers, that contribute to poor performance in linear programming. Additionally, it has been noted in the literature that linear programming can drive economic growth if it is well-connected.

REFERENCE

Abdullah, N., Halim, L., & Zakaria, E. (2014). VStops: a thinking strategy and visual representation approach in mathematical word problem solving toward enhancing STEM literacy. *Eurasia J Math Sci Technol Educ.* 10(3), 165–174. <https://doi.org/10.12973/eurasia.2014.1073a>

- Abijo, J., A. (2014). Assessment of the professional competence of the regular trained and distance learning B. (Ed.) Yoruba Language teachers in Oyo State, Nigeria. *Ilorin Journal of Education.* 33, 25-41
- Abreh, M. K., Owusu, K. A., Amedahe, F., K. (2018). Trends in performance of WASSCE candidates in the Science and Mathematics in Ghana: Perceived contributing factors and the way forward. *Journal of Education*, 198(1), 113-123.
- Adino (2015). Teacher Factors Influencing Pupils' Academic Achievement in Secondary schools in Nyandarua County, Kenya. *Int. J. Educ. Res.*, 1(3), 1-14
- Ahdika, (2017). Improvement of quality, interest, critical, and analytical thinking ability of students through the application of research-based learning (RBL) in introduction to stochastic processes subject, *IEJME - Math. Educ.* 12(2), 167–191.
- Ahn, I. (2014). Relations between teachers' motivation and students' motivation A self-determination theory perspective. West Lafayette, Indiana: Purdue University.
- Aizikovich-Udi, E., and Cheng, D. (2015). Developing Critical Thinking Skills from Dispositions to Abilities: Mathematics Education from Early Childhood to High School, *Creative education.* 6(04), 455
- Allen, K., Kern, M. L., Vella-Brodrick, D., Hattie, J., Waters, L. (2018). What schools need to know about fostering school belonging: Meta-analysis. *Educ. Psychol. Rev.* 30, 1–34.
- Alordia, O. C., Akpadaka, G. and Oviogbodu, O., C. (2015). The influence of gender, school location and socio-economic status on students' academic performance in mathematics. *Journal of Education and Practice.* 6(17), 130-136
- Amir, Z., (2015). Mengungkap Seni Bermatematika Pembelajaran, *Suska journal of Mathematics Education.* , 1(1), 60 – 67
- Andriyani, K. & S. Fahmi, (2020). The Development of a Braille Geometry Module Based on Visual Impairment Students Synthetic Touch Ability with RMT Approach, *AIP Conference Proceedings*, 2215, 060001
- Asempapa R., S. (2022). Examining practising teachers 'knowledge and attitudes toward mathematical modelling. *Int J Educ Math Sci Technol (IJEMST).* 10(2), 272–292. <https://doi.org/10.46328/ijemst.2136>
- Ball, D. L. & McDiarmid, G., W. (2010). *The Subject Matter Preparation of Teachers.* Handbook for Research on Teacher Education. New York: Macmillan.
- Bao, Z., Xu, Y., Li, W., Wang, X., Li, M. R., Li, J. H., & Yang, H. S. (2020). A Birandom Chance-Constrained Linear Programming Model for CCHP System Operation Management: A Case Study of Hotel in Shanghai, China. *Mathematical Problems in Engineering*, 2020, 1-16. <https://doi.org/10.1155/2020/1589415>
- Bell, S., Devecchi, C., Mc Guckin, C., & Sheylin, M. (2016). Making the transition to post-secondary education: opportunities and challenges experienced by students 169 with ASD in the Republic of Ireland. *European*

- Journal of Special Needs Education*, 32(1), 54 - 70. <http://dx.doi.org/10.1080/08856257.2016.1254972>
- Blum, Werner. (2015). Quality Teaching of Mathematical Modelling: What Do We Know, What Can We Do? *The Proceedings of the 12th International Congress on Mathematical Education*. 73-96
- Boucher, C., (2023). *A Simple, Standard Linear Programming Scenari, Wolfram Demonstratisproject*. Retrived on June 1, 2023. from <http://demonstrations.wolfram.com/ASimpleStandardLinearProgrammingScenario/>
- Budiman, A., Samani, M., Rusijono, R., Setyawan, W. H., & Nurdyansyah, N. (2020). The development of direct-contextual learning: a new model on higher education. *International Journal of Higher Education*. 10(2), 15.
- Capraro, M. M., & Joffrion, H. (2006). Algebraic equations: Can middle-school students meaningfully translate from words to mathematical symbols? *Reading Psychology*. 27, 147-164. <https://doi.org/10.1080/02702710600642467>
- Changwe, R. & Mulenga, I. M. (2018). Mathematics Teacher Education Curriculum at a University in Zambia. Student Teachers' Acquisition of Appropriate Competencies for Teaching Mathematics in Secondary School. *Multidisciplinary Journal of Language and Social Sciences Education*. 1(1), 207-242.
- Cortázar, A. (2015). Long-term effects of public early childhood education on academic achievement in Chile. *Early Childhood Research Quarterly*, 32, 13-22.
- Damopolii, I., Wambrauw, H. L., & Mutmainah, S. (2021). Students' perceptions of the full-day school application: Its relationship toward science learning motivation. *Jurnal Pendidikan Dan Pengajaran*, 54(1), 91-100.
- Dorn, N., Berges, M., Capovilla, D., & Hubwieser, P. (2018). Talking at Cross Purposes- Perceived Learning Barriers by Students and Teachers in Programming Education. *Proceedings of the 13th Workshop in Primary and Secondary Computing Education*, 1-4.
- Dude, S. (2020). Contextual teaching and learning model with inquiry method in student learning outcomes. *JournalNX- A Multidisciplinary Peer Reviewed Journal*, 6(1), 113-121.
- Ekowati, C. K., Darwis, M., Upa, H. M. D. P., & Tahmir, S. (2015). The application of contextual approach in learning mathematics to improve students' motivation at SMPN 1 Kupang. *International Education Studies*, 8(8), 81-86. <https://doi.org/10.5539/ies.v8n8p81>
- Evans, J., R. (2020). *Business Analytics*. 3rd Edition, Pearson, New Jersey.
- Examinations Council of Zambia. (2016). *Examinations Performance Review Report 2016*, Examinations Council of Zambia, Lusaka.
- Examinations Council of Zambia. (2017). *ECZ in Perspective*. News about the Examinations Council of Zambia, 10. Lusaka: ECZ.
- Examinations Council of Zambia. (2019). *Examinations Performance Review Report 2019*, Examinations Council of Zambia, Lusaka.
- Fan, W., Williams, C. (2018). The mediating role of student motivation in the linking of perceived school climate and achievement in reading and mathematics. *Front. Educ*. 3, 50.
- Fitri, R. M. T., Sumaryanto F., and A. Rifa'i RC, (2019). Thematic Learning Strategy of Teacher to Slow Learners in Inclusive Elementary School. *Educ. Manag.*, 8(1), 124-130, 2019.
- Fletcher, J. (2018). Performance in Mathematics and Science in basic schools in Ghana. *Academic Discourse: An International Journal*, 10(1), 1-18.
- Gómez, J. C. O., Tabares-Urrea, N., & Ramírez-Flórez, G. (2020). AHP difuso para la selección de un proveedor 3PL considerando el riesgo operacional. *Revista ELA*, 17(33), 1-17.
- González-Gallardo, S., Ruiz, A.B., Luque, M. (2021). Analysis of the Well-Being Levels of Students in Spain and Finland through Interval Multi objective Linear Programming. *Mathematics*, 9, 1628. <https://doi.org/10.3390/math9141628>
- Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA paediatrics*, 169(9), 822-829.
- Herold J., F. (2014), A Cognitive Analysis of Students Activity: An example in mathematics, *Australian Journal of Teacher Education*, 2014, 39(1), 137-158
- Hess, R. D., Chang, C. M., & McDevitt, T. M. (1987). Cultural variations in family beliefs about children's performance in mathematics: Comparisons among People's Republic of China, Chinese-American, and Caucasian-American families. *Journal of Educational Psychology*, 79(2), 179
- Ho, D. y, F. (1994). Cognitive socialisation in Confucian heritage cultures. In P. M. Greenfield & R. R. Cocking (Eds.), *Cross-cultural roots of minority child development*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc.
- Idris, Sulfiaty, (2015). Peningkatan Hasil Belajar Program Lienar Melalui Strategi Pembelajaran Inkuri dan Geogebra Siswa Kelas XII IPA1 SMA 1 Tompobulu. *Mathematics and Education*, 2(3)
- Iheanachor, O., U. (2017). The Influence of Teachers Background, Professional Development and Teaching Practices on Pupils Achievement in Mathematics in Lesotho.
- Julius E, Abdullah A., H, Suhairom N. (2018). Attitude of students towards solving problems in algebra: a review of Nigeria secondary schools. *IOSR J Res Method Educ.*, 8(1), 26-31. <https://doi.org/10.9790/7388-0801032631>
- Kaabo, E., (2019). Teachers' Strategies in the teaching of Linear Programming in Selected Secondary Schools in Monze district - Zambia, a dissertation, the university of Zambia Lusaka.
- Kafata, F. & Mbetwa, S., K. (2016). An Investigation into The Failure Rate in Mathematics and Science at Grade Twelve (12) Examinations and Its Impact to The School of Engineering: A Case Study of Kitwe District of Zambia. *International Journal of Scientific &*

- Technology Research*, 5(8), 71- 93
- Kenney, R. A.m. T, Kim, S. H., Uhan, N. A, Yi, J. S., Shamsul. A., (2020). Linear programming models: identifying common errors in engineering students' work with complex word problems. *Int J Sci Math Educ* 18(4),635–655. <https://doi.org/10.1007/s10763-019-09980-5>
- Kern, M. L., Waters, L. E., Adler, A., White, M. A., (2015). A multidimensional approach to measuring well-being in students: Application of the PERMA framework. *J. Posit. Psychol*, 10, 262–271
- Khafidah, W., Wildanizar, W., Tabrani, Z. A., Nurhayati, N., & Raden, Z. (2020). The application of wahdah method in memorising the qur'an for students of SMPN 1 Unggul
- Koji Samuel, H.M. Mulenga and Mukuka Angel. (2016). An Investigation into Challenges Faced by Secondary School Teachers and Pupils in Algebraic Linear Equations: *Journal of Education and Practice*, 7(26).
- Kosarenko, N. N., Kulakov V. V., Ostroushko, A. V., Murkshtis M. Y., and Nevskiy S. A., (2016). The formation of social and cultural immunity of university students: Educational governance mechanisms. *IEJME - Math. Educ.*, 11(8), 3037–3047, 2016.
- Kumar J. (2018). Teachers And students' perceptions and experiences of mathematics assessments in Fiji: a case study of a rural and an urban primary school. [Master's thesis]. Pretoria (South Africa), University of the South Pacific
- Kusmaryanto, I. (2014). *the importance of mathematical power in mathematics learning*. Semarang State university. Retrieved on July 1, 2019 from <https://www.researchgate.net/publication/303459705>
- Lamichhane, K. (2017). Teaching pupils with visual impairments in an inclusive educational setting: a case from Nepal. *International Journal of Inclusive Education*, 21(1), 1-13. <http://dx.doi.org/10.1080/13603116.2016.1184323>
- Lampert, M. (2010). Teaching problems and the problems of teaching New Haven, CT: Yale University Press.
- Lasco, M & Raganas, N. (2016). Performance-Based Learning Experiences and Achievement of Grade VII Freshmen in Elementary Algebra 1: Effective Inputs for the Enhancement of the K-12 Teaching Guide. Retrieved from file:///C:/Users/TEMPLAPTOP-EJ478O5S.015/Downloads/10-7-PB%20(1).pdf
- Lee, Y., Capraro, R. M., N Capraro, M. M. (2018). Mathematics teachers' subject matter knowledge pedagogical content knowledge in problem posing. *International Electronic Journal of Mathematics Education*, 13(2), 75-90
- Liouaeddine Meriem 1, Bijou Mohammed, and Naji Faïrouz (2017). The Main Determinants of Moroccan Students' Outcomes; *American Journal of Educational Research*, 5(4), 367-383
- Liu, T., Holmes, K., & Albright, J. (2015). Predictors of mathematics achievement of migrant children in Chinese urban schools: A comparative study. *International Journal of Educational Development*, 42, 35-42.
- Luneta, (2022). Effects of Training in Strategic Questioning on Children's Problem-Solving Performance. *Journal of Educational Psychology*, 83(3), 307–317
- Martins, V. F., de Almeida Souza Concilio, I., & de Paiva Guimarães, M. (2018). Problem based learning associated with the development of games for programming teaching. *Computer Applications in Engineering Education*, 26(5), 1577–1589
- Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child development research*, 2012. <http://dx.doi.org/10.1155/2012/876028>
- Mbugua, K. Z., Kibet, K., Muthaa, M, G. and Nkonke R.G. (2012). Factors Contributing to Pupils Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya: A case of Baringo County, Kenya. Chuka University College.
- Mhiliwa, A. J. (2015). The effects of school location on learner's academic performance: A Case of Community Secondary Schools in Makambako Town Council, Njombe. A Dissertation submitted for the Degree of Masters of Education in Administration, Planning and Policy Studies of the Open University of Tanzania.
- MOGE report, (2018). School Certificate and General Certificate Examiners Reports October/ November 2016 Examinations. Chief Examiners Report.
- Mohammed, A. R., & Kassem, S. S. (2020, February). Product Mix Optimization Scenarios: A Case Study for Decision Support Using Linear Programming Approach. In 2020 *International Conference on Innovative Trends in Communication and Computer Engineering (ITCE)* (pp. 50-55). IEEE. <https://doi.org/10.1109/ITCE48509.2020.9047758>
- Mohammed, A.R. and Kassem, S.S. (2020). Product Mix Optimization Scenarios: A Case Study for Decision Support Using Linear Programming Approach. 2020 *International Conference on Innovative Trends in Communication and Computer Engineering, Aswan*, 8-9 February 2020, 50-55. <https://doi.org/10.1109/ITCE48509.2020.9047758>
- Moschkovich, J. (2018). Talking to learn mathematics with understanding: Supporting academic literacy in mathematics for English learners. In *Language, Literacy, and Learning in the STEM Disciplines*, 13-34. Abingdon, Oxfordshire, UK: Routledge.
- Muis, K. R., Pekrun, R., Sinatra, G. M., Azevedo, R., Trevors, G., Meier, E., & Heddy, B. C. (2015). The curious case of climate change: Testing a theoretical model of epistemic beliefs, epistemic emotions, and complex learning. *Learning and Instruction*, 39, 168–183
- Mulenga, I., M. & Kabombwe, Y., M. (2019). A Competency-Based Curriculum for Zambian Primary and Secondary Schools: Learning from Theory and

- some Countries around the World.
- Mulenga, I., M. (2015). English Language Teacher Education Curriculum Designing: A Mixed Methods Analysis of the Programme at the University of Zambia. PhD Thesis. The University of Zambia.
- Munawar S, S& Muhammad, Z., I. (2014). Impact of collaborative teaching (CT) on mathematics pupils' Achievement in Pakistan, *Journal of research and Reflections in Education*, 8(1), 13-21.
- Mwambazi, C. M., Mubanga, L., & Francis, S. (2023). Disablers Affecting Pupils Academic Performance in Linear Programming at Nkeyema Secondary School in Zambia: A Hermeneutic Perspective. *American Journal of Multidisciplinary Research and Innovation*, 2(3), 1-8. <https://doi.org/10.54536/ajmri.v2i3.1454>
- Mwanza, C. and Silukuni, D. (2020). Implementation of the Free Education Policy in Primary Schools in Kafue District: Is it a Compromise on Quality of Education in Zambia? *European Journal of Education Studies*, 7(9), 317-333
- Nakhanu, B., Shikuku and Wasike. (2015). Problem based learning and its effect on Kenyan Secondary School students learning outcomes in linear programming. *Point Journal of Educational Research and Behavioural Sciences*, 1(2), 001-008. Kakamega, Kenya.
- NCDC (2018). The lower secondary curriculum: mathematics syllabus. Kampala, Uganda
- Ngussa, B. M., Mbuti, E. E. (2017). The Influence of Humour on Learners' Attitude and Mathematics Achievement: A Case of Secondary Schools in Arusha City, Tanzania. *Journal of Educational Research*, 2(3), 170 –777
- Nixon, R. S., Toerien, R., & Luft, A. J. (2018). Knowing more than their students: Characterising secondary science teachers' subject matter knowledge. *School Science and Mathematics*, 119, 150–160.
- Nkhata, B., Shamapango, L. B., Mwanakatwe, Y. M. L., Mumbula, Y. & Tailoka, F. (2018). Mathematics Grade 12 (Teacher's Book), Zambia Secondary School Syllabus. Lusaka: Zambia. Macmillan Publishers (Zambia) Ltd.
- OECD. PISA. (2018). Results; OECD Publishing: Paris, France, 2019.
- Olusegun, S. (2015). Constructivism learning theory: a paradigm for teaching and learning. *J Res Method Educ* 5(6), 66–70. <https://doi.org/10.9790/7388-05616670>
- Opolot-Okurut, C. (2010). Classroom learning environment and motivation towards mathematics among secondary school students in Uganda. *Learning Environments Research*, 13, 267-277. <https://doi.org/10.1007/s10984-010-9074-7>
- Painagoni, K. (2018). Role of Teachers and Parents in Honing Their Hidden Talents of Slow Learners. *Int. J. Adv. Research*, 5(3), 3–6
- Paul, R. and Elder, L. (2012). Critical Thinking: Competency Standards Essential to the Cultivation of Intellectual Skills, Part 5. *J. Dev. Educ.*, 36(1), 30–31, 2012.
- Phakeng, M. S., N. Planas, A. Bose, and E. Njurai. (2018). "Teaching and learning mathematics in trilingual classrooms: Learning from three different continents." In *Mathematical discourse that breaks barriers and creates space for marginalised learners*, 277-293. Leiden, Netherlands: Brill Sense.
- Pongsakdi, N., Laakkonen E., Laine, T., Veermans, K., Hannula-Sormunen M., M, Lehtinen E. (2019). The role of beliefs and motivational variables in enhancing word problem solving. *Scand J Educ Res* ,63(2), 179–197. <https://doi.org/10.1080/00313831.2017.1336475>
- Pongsakdi, N., Anu, K., Koen, V., Kalle, L., Marja, V., and Erno, L., (2020). What Makes Mathematical Word Problem Solving Challenging? Exploring the Roles of Word Problem Characteristics, Text Comprehension, and Arithmetic Skills. *ZDM—Mathematics Education* 52 (1), 33–44
- Pradeep, M. D. and Aithal, S. (2015). Learning Through Team Centric Exercise & Key Point Pedagogy- An Effective Learning Model for Slow Learners in Social Work Higher Education Training Pradeep, *Munich Pers. RePEc Arch.*, 71951, 2015.
- Puteri, L., H. (2018). The Apperception Approach for Stimulating Student Learning Motivation. *International Journal of Education, Training and Learning*, 2(1), 7-12.
- Putranto. S. and Marsigit, M. (2018). Is it Effective using Peer Tutoring with a Realistic Mathematics Education Approach to Improve Slow Learners' Mathematics Attitudes? *Int. J. Emerg. Maths. Educ.*, 2(2), 179–186, 2018.
- Qian, Y., Hambrusch, S., Yadav, A., Gretter, S., & Li, Y. (2020). Teachers' Perceptions of Student Misconceptions in Introductory Programming. *Journal of Educational Computing Research*, 58(2), 364–397
- Sakayombo, J. (2018). Learners Low Performance in School Mathematics: A Result of their Insufficient Acquisition of Ethno mathematics. *Zambia Journal of Teacher Professional Growth (ZJ TPG)*, 4(1), 55-66.
- Simui, F. (2018). Lived experiences of students with visual impairments at Sim University in Zambia: A hermeneutic phenomenological approach. [Unpublished Doctoral Thesis, University of Zambia]. <http://dspace.unza.zm/handle/123456789/5884>
- Skemp, R. (1971). *The Psychology of Learning Mathematics*. Penguin Books.
- Smith, J. A., & Johnson, K. L. (2018). the primary tenant strategy for the development of students' conceptual application skills. *Journal of education*, 45(2), 123-136. doi:10. xxx/xxxx
- Stevenson, M. (2020). Growth of pedagogical content knowledge and 'understanding mathematics in-depth: Conceptions of pre-service teachers. *Teacher Development*, 24(2), 65–183.
- Sudihartini, E. (2019). Facilitating Mathematical Understanding in Three-Dimensional Geometry Using the SOLO Taxonomy. *Erudio Journal of Educational Innovation*, 6(1), 11–18. <https://doi.org/10.1080/00313831.2017.1336475>

- org/10.18551/erudio.6-1.2
- Sukoriyanto and Nuri Desmayanti. (2021). Analysis of Student errors in solving linear programming problems based on Newman's procedures in terms of writing mathematical communication capabilities *AIP Conference Proceedings* 2330, 040002 (2021). <https://doi.org/10.1063/5.0043383>
- Sun, R., Zhang, B., & Liu, T. (2016). Ranking web service for high quality by applying an improved Entropy-TOPSIS method. 2016 *17th IEEE/ACIS International Conference*.
- Suyitno, A., Hardi, S. (2015). Learning Therapy for Students in Mathematics Communication Correctly. Based on Application of Newman Procedure (A case of Indonesian Students), *international journal of Education Research* 2015, 3(1), 529-538. the University of Zambia Lusaka. The University of Zambia.
- Tsamir, P. & Nava, A. (2015). "Students' Strategies and Difficulties: The Case of Algebraic Inequalities. *International Journal of Mathematical Education in Science and Technology*, 32(4), 513–524
- Tumuti, S. (2015). Students and Teachers Attitude Factors Contributing to Poor Performance in Mathematics in K.C.S.E in selected public secondary schools in Kiambaa Division of Central Province, Kenya. *Strategic Journal of Business and Change Management*, 2(58), 317-332
- UNEB. (2016). Uganda National Examinations Board, report on work of Uganda certificate of examinations candidates. Kampala, Uganda
- UNEB. (2018). Uganda National Examinations Board, report on work of Uganda Certificate of Examinations candidates. Kampala, Uganda
- UNEB. (2020). Uganda National Examinations Board, Report on work of Uganda Certificate of Examinations candidates. Kampala, Uganda
- UNESCO. (2018), Strengthening Peer Learning of Education Policies for SDG 4: The Role of Regional Organizations. 2020 Global Education Monitoring Report Team (GEM Report). Paris.
- Willis, Judy. (2010). A study guide for learning and to love mathematics: teaching strategies that change students' attitude and get results. Oxford.