Impact Of Goal Setting And Note-Taking On Conceptual Understanding Of Mole Concept Among 11th Graders At Broadway Secondary School, Zambia

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Abstract: The study has a dual focus: to investigate variation in five dimensions of executive function skills namely working memory, planning, organisation, metacognition and flexible thinking abilities among 11th graders enrolled for science 5124 syllabus at Broadway Secondary School in Kabwe district of Zambia; and to investigate the impact of goal setting and note-taking (executive function skills instruction strategies) on conceptual understanding of mole concept among pupils with self-reported weak executive function skills. Quantitative data was collected using executive function skills inventory-student report and mole concept achievement tests. Results show that there is variation in the distribution of executive function skills among grade 11pupils enrolled for science 5124 syllabus at Broadway Secondary School. Results further show that pupils with self-reported weak executive function skills who had received training in goal setting and note-taking outperformed pupils with self-reported strong executive function skills who were not trained in goal setting and note-taking. Goal setting and note-taking show to have positive impact on conceptual understanding of threshold concepts such as mole concept on learners especially those with weak executive function skills.

Key words: chemistry education, executive function skills, goal setting, note-taking, mole concept.

1. Introduction

One of the general aims of teaching chemistry reflected in the Zambian Secondary School Chemistry curriculum is that students should become confident citizens in a technologically advancing world [1]. According to the Ministry of Education, to be a confident citizen entails having the ability to solve problems that one may encounter, not only in a classroom situation but also in everyday life. Being a confident citizen also involves having the ability to think critically, creatively and being able to make appropriate decisions [1]. Diamond and Lee [2] cited four key qualities that characterise a confident citizenry: creativity and strong working memory, flexibility, self-control, and discipline. Creative thinking and strong working memory enable a student to formulate new solutions to current problems and to mentally handle a lot of information with fewer difficulties. Flexible thinking enables the student to appreciate different points of view of handling the same problem whereas self-control helps a student to overcome negative persuasions. Since confident citizens are also leaders of tomorrow, they need to have self-discipline to stay focused [2]. All these qualities used to define a confident citizenry are similar to brain based abilities known as executive function skills (EFS) [3]. Suffice it to mention that there is variations in definitions of EFS [4]. Gioia et al., [5] define executive functions as the supervisory and self-regulatory functions that organise and direct cognitive activity, emotional response, and overt behaviour. Lezak [6] define EFS as the processes that are essential for engaging in independent, purposeful and self-directed behaviours. Dawson and Guare [7] defined EFS as brain based skills that allow us to organise our behaviour over time. The duo further argued that we use EFS every day to manage our lives and achieve our goals, both short term and long term [7]. Laura and Kristin [3], described EFS as a set of mental processes that help us connect past experience with present action and that people use these mental processes to perform activities such as planning, organizing, strategizing, paying attention to and remembering details and managing time and space. Despite the many different definitions, there seem to be a general agreement that the construct encompasses several abilities generated from the frontal region of the brain [4]. In this study, EFS refer to working memory, planning, organisation, metacognition and flexible thinking, abilities that help us connect the past experiences to the present action [3] and are essential for engaging in independent, purposeful and self-directed behaviours [8]. Research has shown that students who have challenges with EFS also have low academic achievement [3], [9], [10]. Furthermore, it has been observed that learning difficulties associated with EFS become more pronounced with increase in complexity of tasks within the curriculum [3]. Particularly, tasks that demand use of working memory, self-regulation, planning, organizing, shifting, and metacognition strategies are said to be more affected [3]. For example, in Science 5124 syllabus, mole concept [1] is one of the many topics

that demands the use of the aforementioned strategies. The topic, consists of several individual but interrelated subtopics. It includes some of the following concepts:

i. quantitative understanding of particulate nature of matter.
ii. molecular weight of compounds and its calculation
iii. construction of balanced chemical equations
iv. determination of ratios of reacting compounds and their products
v. identification of limiting reactant in chemical reaction
vi. calculating percentage mass
vii. calculating percentage yield

Conceptual understanding of mole concept, entail making strong linkages among these individual subtopics [11]. The learning process of mole concept therefore depends greatly on students' ability to connect prior knowledge to new concepts [12] and also on abilities such as self-regulation, planning, organizing, shifting, and metacognition abilities [13]. Therefore, dysfunction in the said abilities could lead to conceptual learning difficulties. As, a threshold concept, conceptual understanding of mole concept, is central in understanding of several other topics within chemistry [14]. This calls for the need to find teaching strategies to use in supporting pupils with learning difficulties due to weak EFS. Meltzer, Laura and Barzillai [15] suggested a two-level intervention approach in addressing learning difficulties associated with weak EFS: the level of the environment and the level of the person. At the level of the environment, interventions must be directed towards changing the classroom environment to a well organised and structured room [15]. At the level of the person, use of explicit and systematic strategy instruction focused at EFS was proposed [15]. Both interventions are said to work as scaffolds in helping the student with executive dysfunction. Arising from the suggested fundamental role of EFS in academic success of students and the proposed school based interventions for Executive Dysfunction, this study attempt to answer two questions: Is the distribution of five dimensions of EFS namely working memory ability, planning ability, organisation ability, metacognition ability and flexible thinking ability the same among grade 11 students enrolled in Science 5124 Ordinary Level Syllabus at the selected Secondary School within Kabwe Town? Does training in goal EFS strategies (setting and note-taking) yield substantial gain in conceptual understanding of Mole Concept among students with weak Executive Function Skills? By Goal-setting, we refer to students' ability to set specific, realistic objectives that can be achieved within a defined period of time [16]. On the other hand, note-taking refers to students' ability to comprehend either a written document or a lecture and recording information by writing it down [17].

1.1 Theoretical Framework of the Study

The study is based on a constructivist's cognition process grounded in neuroscience. The learner actively constructs knowledge through the interaction of prior knowledge and new sensory experiences [18], [19], [20]. EFS coordinate the incoming sensory experiences with prior knowledge [21]. From a well-coordinated communicative encounter between existing knowledge and new incoming sensory experiences, a well-structured body of knowledge is formed which lays a strong foundation for the students' ability to make meaningful connections. Formed knowledge also promotes students' adaptability and survival in any given environment. Figure 1 shows representation of suggested students' cognition process.

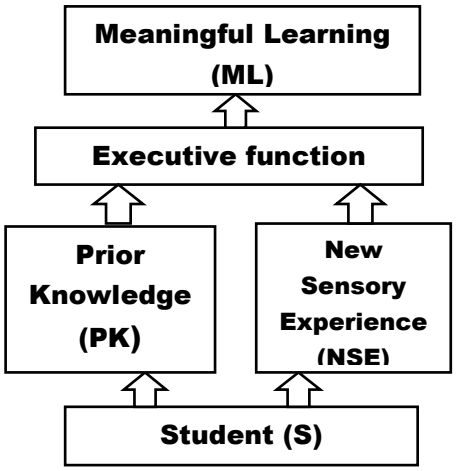

Figure 1: *Cognition process grounded in Neuroscience.*

The model hinges on the understanding that new concepts are anchored on existing schemata [20]. In order to achieve Meaningful Learning (ML), the Student (S) has to coordinate and integrate New Sensory Experiences (NSE) with Prior Knowledge (PK). Central in this learning process are the Executive Function Skills (EFS) that enable the student to direct behaviour towards the attainment of a goal [21]. In addition, there is strong evidence that Executive Function Skills are not rigid [3]. When directly targeted, they are able to develop.

2. Methodology and Methods

This action research study used a quasi-experimental design. Carr and Kemmis [22], describe action research as having three functional roles: the improvement of practice, the improvement of the understanding of practice and the improvement of the situation in which the practice takes place. The design was adopted to help the researcher improve own practice and to improve the performance of pupils in mole concept especially those with weak executive function skills. The study had two stages. The first stage aimed at exploring the distribution of five dimensions of executive function skills (working memory ability, planning ability, organisation ability, metacognition ability and flexible thinking ability) among grade 11 pupils enrolled in Science 5124 syllabus at Broadway Secondary School. The second stage focused at determining the impact of goal setting and note-taking (EFS instruction strategies) on conceptual understanding of mole concept among grade 11 pupils with self-reported weak executive function skills at Broadway Secondary School. Purposive sampling of the context for the study [23] was used in selecting the school for the study. The school is the work place for the researcher making it convenient to undertake the study. Secondly, the school is located in a formerly lead – zinc mining area of Kabwe Town [24] [25] in Central Province. Lead is a developmental neurotoxicant heavy metal, which causes intellectual function impairment and behavioural problems in children [26] . Other than stress, sadness, loneliness, and

poor health [27] lead exposure could be another factor that has negative impact on pupils' executive function skills. The researcher purposively selected all 11th graders (N=166) enrolled for Science 5124 syllabus at Broadway Secondary School for stage one of the study. Restriction on grade and subject was meant to control for possible variation in subject content matter knowledge. In stage two, two groups were purposively formed: the experimental group (n = 42) and the control group (n=38). Level of strength in executive function skills was the basis of group placement (Table 3). Permission to undertake the study was sought from the school administration. In addition, the consent of all participants was obtained through the signing of individual consent form. To ensure confidentiality of participants, the questionnaire and answer booklets for written tests had only participants' identification numbers.

2.1 Research Instruments

Two research instruments were used: the executive function skills inventory-student report and the mole concept achievement tests. The executive function skills inventory-student report, is a self-administered questionnaire designed to assess students' perception of own executive function skills [7], [28]. The questionnaire contained 15 item statements, 3 on each of the 5 dimensions of EFS. A participant had to rate himself or herself to the degree that the three statements on each EFS best described him or her on a seven point Likert Scale (strongly disagree = 1, disagree = 2, tend to disagree =3, neutral = 4, tend to agree = 5, agree = 6, or strongly agree =7). To determine the score on each EFS, all three sub-scores on three statements were summed up. The highest possible score on each dimension of EFS was 21 while the lowest score was 3. To determine the distribution of EFS, individual EFS scores were coded into three categories (Table 3): low score (range 3 – 11), average score (range 12 – 16) while from 17 to 21 was coded as high score (range 17 – 21). The instrument was adopted for its ability to measure the behaviour in a real world context [5], [29], [30] . In addition, the instrument was easily accessible, affordable, easy to administer and based on literature [28]. Mole concept achievement tests were pen and paper tests designed by the researcher. The pre-test had ten questions and the post-test had 8 questions from Mole Concept topic. The test questions were set to determine the conceptual understanding of the Mole Concept. To be specific, question 8 in mole concept achievement post-test part (a) required learners to define a limiting reactant. In part (b) given that 2.4g of magnesium was made to react with 0.30mol of hydrochloric acid:

i. write a balanced chemical equation for the reaction
ii. determine the limiting reactant
iii. calculate the mass in excess for the substance which was in excess.

It was expected that, in order for the learner to correctly answer the question, he or she had to analyse the question and determine the vital information given in the question. Secondly, the student was expected to plan by figuring out what was being required of him or her in the question. The third step was for the pupil to compute the necessary steps in order to determine the answer. The last expectation was for the pupil to evaluate the answers given.

2.2 Goal Setting Strategy

The activity focused on enhancing pupils' ability to break down tasks into manageable parts [31]. Pupils, while working in groups of six, were asked to come up with a home work study plan on Acids, Bases and Salts, topics they had already learnt. They started by timing themselves and then monitored the actual time they spent on the activity. This strategy directly focused at helping students develop the ability to understand the objective of a particular task, visualize the steps of the task, organize time effectively, and determine the resources needed to complete the task. The strategy was premised on the understanding that when learners set their own goals, they show greater commitment and are more motivated to attain these goals. Table 1 presents the scheme of work for goal setting strategy training.

Table 1: *Scheme of work for goal setting strategy training.*

Topic	Session/ Duration	Outcomes:	Activity/Material
Planning and goal Setting	1st Session 60 minutes	Describe the concept of planning and goal setting Discuss the importance of planning and setting of goal	Activity: Introduction on purpose of the program.
	2nd Session 60 minutes	Discuss what constitutes a goal and a good plan.	Activity: Participants to work in groups of 6 to develop study plans for Acids, Bases and Salts.

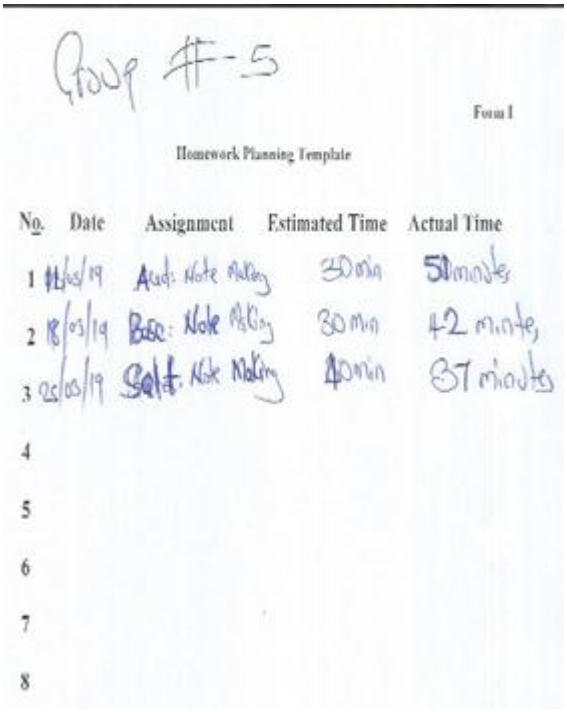

Figure 2 *shows a sample of homework plan for group 5.*

The group underestimated the first two activities. The topic acids was allocated 30 minutes however actual average time spent was 51 minutes. The time estimated on bases was 30

minutes however, the actual average time spent was 42 minutes. On the last topic salts, the time estimated was 40 minutes while actual average time spent was 37 minutes. This difference in time allocation could be due to pupils' failure to set realistic goals. With training, pupils developed the ability to understand the objective of a particular task, visualise the steps of the task, organize time effectively, and determine the resources needed to complete the task

2.3 Note-taking strategy

Note-taking strategy focused on training pupils the ability to comprehend either a written document or a lecture and record information by writing it down in a systematic way [32]. With the aid of a Note-Taking Template [15], pupils worked in groups of 6 to make summary notes on acids, bases and salts. According to Meltzer, Laura and Barzillai [15], note-taking is a complex process that puts heavy demand on students. The need to coordinate and integrate multiple processes that include listening, differentiating main points from irrelevant information becomes more challenging to students with low EFS.

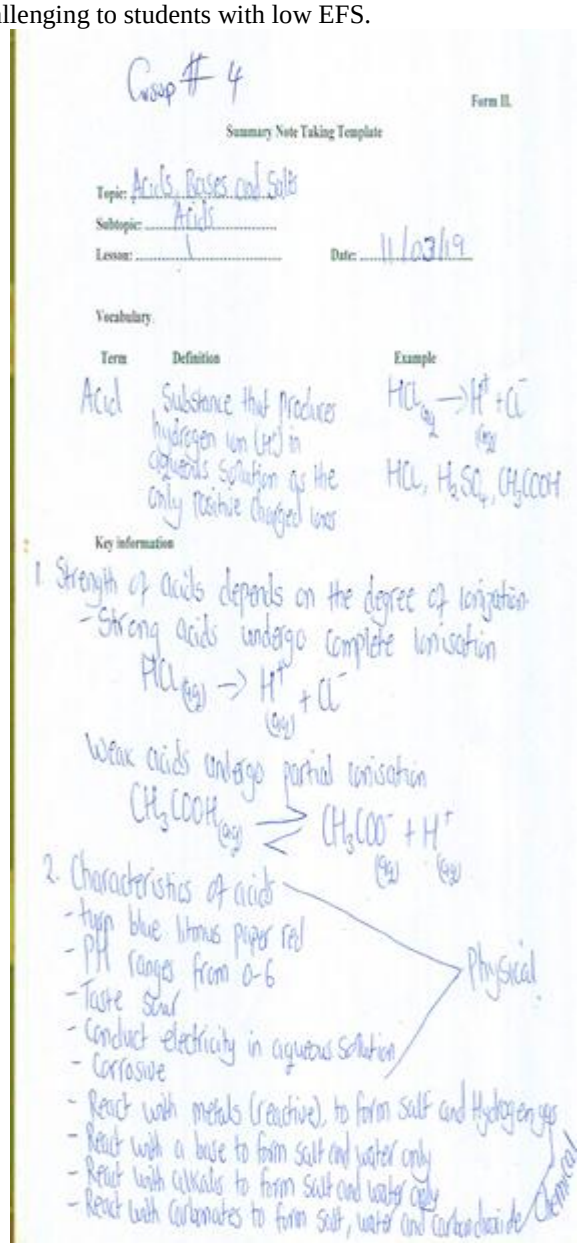

Figure 3: *Sample summary notes on Acids produced by group 4.*

Table 2: *Scheme of work for note-taking strategy tanning.*

Topic	Session/ Duration	Outcomes	Activity/Material
Organisation and prioritisation ability	3rd Session 60 minutes	Develop a systematic approach for organising note taking	**Activity:** Students work in groups of 6 and practice use of note-taking template sheet
	4th Session 60 minutes	Develop a systematic approach for organising lesson notes.	**Material:** Note-taking template

Figures 3,4 and 5 are samples of notes on Acids, Bases and Salts prepared by students.

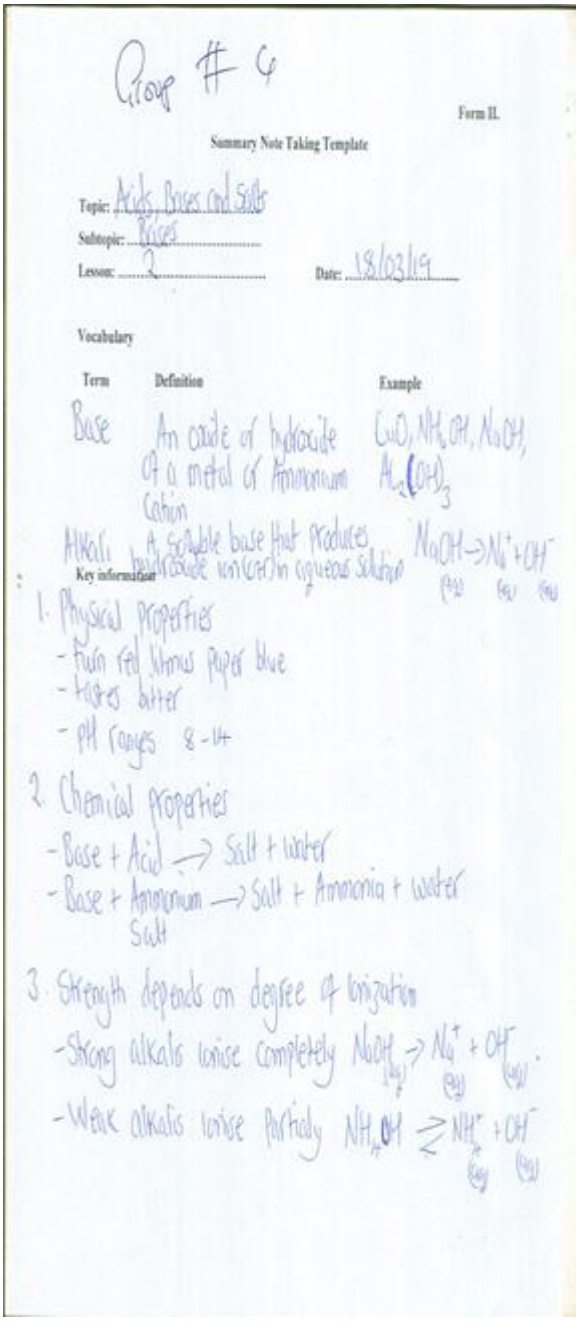

Figure 4: *Sample summary notes on Bases produced by Group 4.*

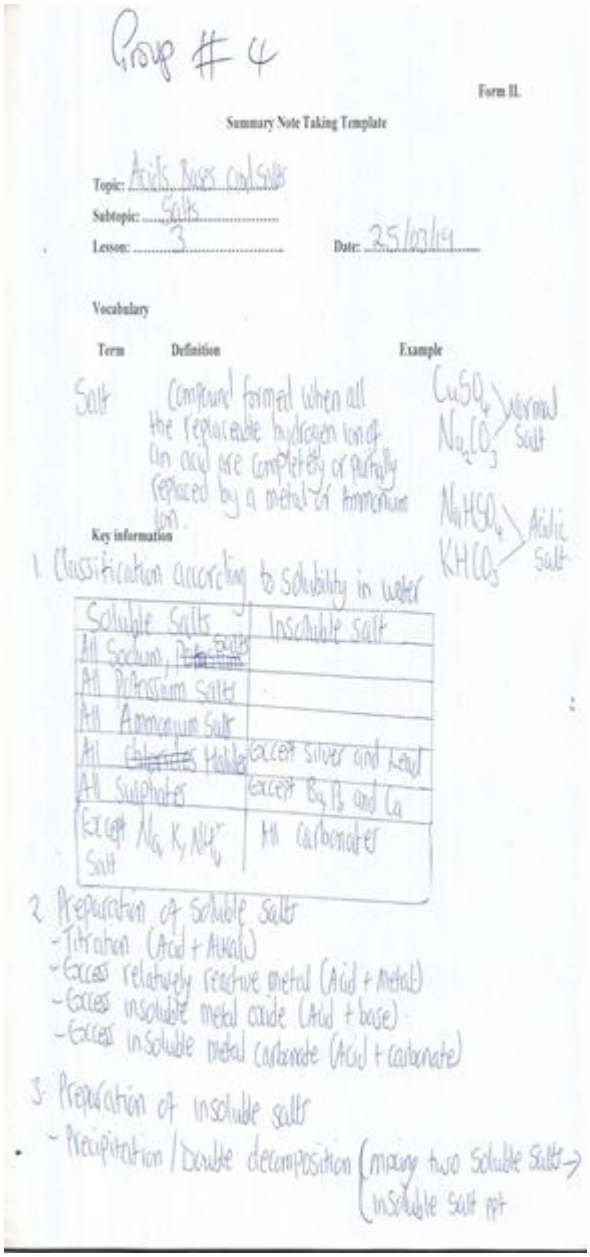

Figure 5: *Sample summary notes on Salts produced by Group 4.*

3. Results

3.1 Distribution of Executive Function Skills

Table 3 presents distribution of pupils according to strength in EFS.

Table 3: *Variation in strength of EFS among pupils (N= 166)*

Variable	Students with		
	Low Mark (3 – 11)	Average Mark (12 – 16)	High Mark (17 - 21)
Working Memory	61	74	31
Planning	50	63	53
Organisation	42	56	68
Metacognition	39	78	49
Flexible Thinking	41	65	60

Table 3 show that 61 of 166 pupils reported to have weak working memory ability. This means that 37 % of 11th graders identified themselves to have weak working memory ability. 31 of 166 pupils, that is 18 % of grade 11 pupils, reported to have strong working memory ability. With regards planning ability, 50 of 166 pupils, that is 30% of the pupils, reported to have weak planning ability while 53 of 166 pupils, that is 32%, reported to have strong planning ability. On organisation ability, 42 of 166 pupils translating to 25%, reported to have weak organisation ability while 68 of 166 pupils which is 41%, reported to have strong organisation ability. With regards to metacognition ability, 39 of 166 pupils, that is 23% of the pupils, reported to have weak self-monitoring ability while 46 of 166 pupils (27%) reported to have strong metacognition ability. On flexible thinking ability, 41 of 166 pupils (25%) reported to have weak flexible thinking ability while 60 of 166 pupils (36%) reported to have strong flexible thinking ability. Table 3 confirm presence of variation in the distribution of EFS among grade 11 pupils enrolled for Science 5124 syllabus at Broadway Secondary School. The observed difference in the strength of EFS suggest difference in pupils' ability to connect prior knowledge to new concepts [12] and also in abilities such as self-regulation, planning, organizing, shifting, and metacognition [13].

3.3 Goal setting, note-taking and mole concept achievement tests.

To investigate the impact of goal setting and note-taking on conceptual understanding of mole concept, a mole concept achievement pre-test was administered to both the experimental group (n = 42) and the control group (n = 35). Table 4 presents results for the independent sample t-test, comparing the mean scores in mole concept achievement pre-test between the experimental group and the control group (N = 80).

Table 4: *Results comparing the mean scores in Mole Concept Achievement Pre-Test between the experimental group and the control group.*

Variable	N	Mean	SD	df	t – value	p – value
Experimental Group	42	25.03	10.83	78	1.258	.212
Control Group	38	24.04	9.92			

Table 4 show that there was no significant difference on mean scores in mole concept achievement pre-test between the experimental group (N=42, M = 25.03, SD=10.83) and the control group (N=38, M= 24.04, SD =9.92). Both groups were at the same level on conceptual understanding of the mole concept. The results however, are contrary to the expected results. Pupils with weak self-reported low EFS were expected to have lower mean score mark compared to pupils with self-reported strong EFS. However both groups, the experimental group (n = 42) and the control group (N = 38) had almost the same mean scores (M = 25.0) and (M = 24.0) respectively. Mann, Snover, Boyd, et al. [33] argue that a self-administer EFS behavioural rating inventory must be used together with EFS behavioural rating inventory - parent report and EFS behavioural rating inventory - teacher report. The protocol is aimed at controlling for false self-rating that may arise due to impaired self-awareness [4]. In

this study only a self-administer EFS behavioural rating inventory was used. Parents and teachers had not taken interest in profiling pupils' EFS. It is likely, that learners in both, the experimental group and control group had wrongly rated themselves due to impaired self-awareness. Nevertheless, since the pupils' self-rating represented lived experience [5], the data collected was meaningful. Table 5 presents independent sample t-test results comparing the mean scores in mole concept achievement post-test between the experimental group and the control group (N = 80).

Table 3: *Independent sample t-test results comparing the mean scores in Mole Concept Achievement Post-Test between the experimental group and the control group (N = 80).*

Variable	N	Mean	SD	df	t – value	p – value
Experimental Group	42	33.9	13.5	78	3.026	.003
Control Group	38	27.9	11.8			

The findings (Table 7) shows that there was a significant difference in conceptual understanding of Mole Concept between the experimental group (N= 42, M=33.9, SD = 13.5) and the control class (n =38 M= 27.9, SD = 11.8). The experimental group performed better (M =33.39) than the control group (M =27.9). Figure 6 illustrate gain in conceptual understanding of mole concept among pupils exposed to goal setting and not-taking strategies compared to pupils not exposed to goal setting and not-taking strategies.

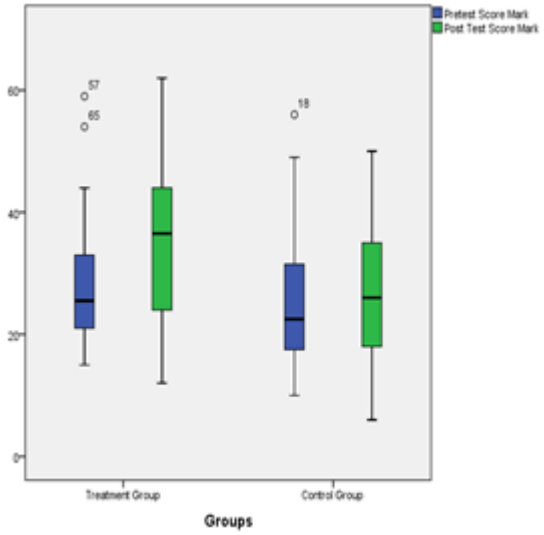

Figure 6: *Performance of experimental and control groups on pre-test and post-test in mole concept achievement tests.*

The experimental group also referred to as the treatment group (n=42), in mole concept achievement pre-test, obtained a mean score of 25.0 and standard deviation of 10.8. In mole concept achievement post-test, the same group obtained a mean score of 33.9 with the standard deviation of 13.5. The control group got a mean score of 24.0 in mole concept achievement pre-test, with standard deviation of 9.9. In mole concept achievement post-test, the control group got a mean score of 27.0 with the standard deviation of 11.8. The experimental group, having received training in goal setting and note-writing, recorded significant gain in mole concept achievement post-test (33.9 – 25.0 = 8.9). On the other hand, the control group who had not received training in goal setting and note-writing only reported marginal improvement (27. – 24.0 = 3.0)

4.0 Discussion

The findings confirmed presence of variation in the distribution of the five dimensions of EFS among grade 11 students enrolled for Science 5124 subject. In the context of this study, the effect of the observed deficiency in EFS on the conceptual understanding of mole concept could be explained in relations to Vygotsky's theory of Zone of Proximal Development [19]. Figure 7 illustrates the concept of Zone of Proximal Development.

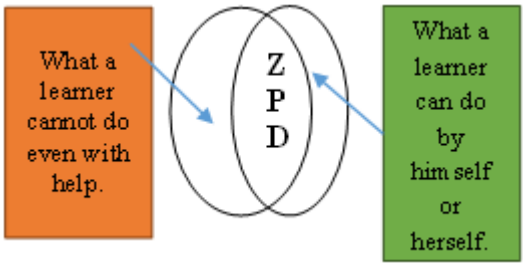

Figure 7: *Zone of Proximal Development.*

The construct, 'Zone of Proximal Development' is used to refer to the distance between the upper bound of what a student can do by himself or herself and the lower bound of what a student cannot do even with support from teachers and peers [19]. However, having challenges EFS narrows down both the upper bound of what a student can do by himself or herself and the lower bound of what a student cannot do even with support from teachers and peers [34]. Figure 8 illustrates the diagrammatic representation of Zone of Proximal Development for a student with Executive Function Skills deficit.

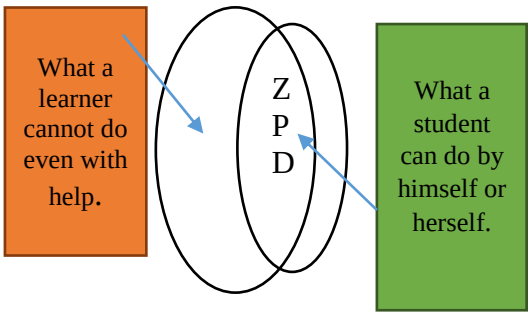

Figure 8: *Zone of Proximal Development for a student with Executive Function Skills deficit.*

Students with challenges in the five dimension of EFS are likely to have a number of challenges in understanding mole concept. In relation to weak working memory, the ability to hold information while working on any given task, pupils are likely to have difficulties in identifying and applying information required to solve various tasks in mole concept. Deficit in planning and organisation abilities could cause difficulties in imposing structure and order on ideas, a key component in being able to independently solve problems in mole concept [11]. Flexible thinking deficit implies that

students are likely to get stuck with the established order even when it requires a change of strategy. Knowledge of variation in EFS among pupils enrolled for Science 5124 syllabus must constitute teachers' knowledge about the student (Mansor, R., Halim, L., B, Osman, K., 2010). This is part of the knowledge that the teacher has to use when designing classroom instructions and ways to support students with learning difficulties due to weak EFS (Watson, S. M. R., Gable, R. A., & Morin, L. L. , 201). Further, this knowledge could be used during formation of working groups in the classroom. Other than relying on the usual male-female criteria, EFS profile can also be used to avoid placing students with weak EFS or strong EFS in the same group. In so doing, the More Knowledgeable Other, among students can support other students.

4.1 Goal setting, note-taking strategies and conceptual understanding of mole concept.

The findings show that students who had been exposed to goal setting and note taking strategies performed better than students who were not exposed to goal setting and note taking strategies. The two strategies were taught using acids, bases and salts. However, students in the experimental group seem to have used the acquired knowledge on new content and context of problem solving in Mole Concept. Figure 9 shows diagrammatic representation of Zone of Proximal Development for students after goal setting and note-taking strategies instruction.

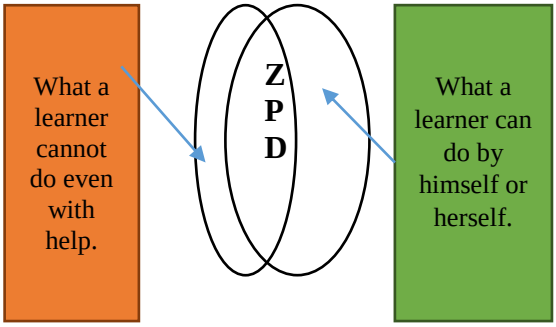

***Figure 9**: Zone of Proximal Development after goal setting and note-taking strategies instruction*

The findings of this study are in agreement with prior investigations. Meltzer [16], observed that when students set their own goals, they show greater commitment and motivation in working towards achieving the set goals. In so doing, goal setting actively enhances effectiveness, achievement, and motivation among students. On the other hand, independent note-taking increases class participation and improves the recall of material among students [35]. Note-taking improves learner performance by improving knowledge structure in students' mind. In addition, improved note-taking skills was noted to improve students' comprehension, short-term and long-term recall ability [36]. The observed improved performance for students who had received instruction on goal setting and note-taking can be attributed to improved knowledge structure in students' mind. This made it easier for them to recall learnt material, analyse the tasks, plan the steps, execute the tasks and evaluate the results.

5.0 Conclusion.

The study has provided evidence showing variation of strength in working memory ability, planning ability, organisation ability, metacognition ability and flexible thinking ability vary among grade 11 pupils enrolled for science 5124 syllabus at Broadway Secondary School. This variation of strength in the five dimensions of EFS strongly suggest deficit in pupils' ability to plan, organise and prioritise information, and pupils' ability to hold and manipulate information in working memory. Training pupils in goal setting and note-taking strategies has shown to remedy learning difficulties of threshold concepts such as the mole concept. This calls for individual subject teacher to have knowledge of variation in EFS among pupils. Secondly, the study has provided evidence that using goal setting and note-taking strategies can be used to enhance conceptual understanding of mole concept, and other threshold concepts, among pupils especially those with weak executive function skills.

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