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Effect of Zone of Proximal Development on the Performance of Learners in Stoichiometry in Selected Secondary Schools in the Zambezi Region, Namibia

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Abstract

This study investigated the effect of the Zone of Proximal Development (ZPD) on the performance of secondary school learners in stoichiometry in three selected schools currently doing Physical Science at Higher and Ordinary levels in the Zambezi Region, Namibia. Structured questionnaires were used to collect information bothering on learners' knowledge of stoichiometry contents, perceived factors affecting learners' performance in stoichiometry and strategies for improvingperformance in stoichiometry. A total of 83 participants from four secondary schools were randomly selected to fill the questionnaires. The results obtained showed that only 29.25% of the participants indicated that they have good knowledge of stoichiometry to solve related problems while 55.50% disagreed and 15.25% were undecided. On the perceived factors affecting learners' performance in stoichiometry, it was found that only 28.25% of the participants indicated that they understand the principles of stoichiometry while majority indicated lack of understanding of the principles such as reactant-reactant pair and reactant-product pair needed to effectively plan solution to stoichiometry problem. There is also lack of peer-assisted learning as indicated by the participants. Peer-assisted learning is a very helpful approach to solving general academic problems as learners could easily discover useful tips through exchanging of ideas. On the strategies for improving performance in stoichiometry, only 13.00% of the participants indicated that they do meet their science teachers for help when solving stoichiometry problems but majority do not and are also not aware of any tutorial class to help week learners in stoichiometry.

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However, the majority (55.75%) of the participants disagreed with the idea whether stoichiometry should be removed from secondary school syllabus. Considering the challenges learners faced in stoichiometry in the study area and majority are still willing to have it on their syllabus, we recommend that further indepth research be carried out to identify specific challenges responsible for learners' poor performances in stoichiometry in the study area and devise remediation measures. There is also need to institute proper strategies that will support learners understanding of stoichiometry taught in secondary schools in the region.

Keywords: Zone of proximal development; stoichiometry; learners' performances; secondary school.

1. Introduction

From the educationist point of view, the Zone of Proximal Development (ZPD) is the difference between what a learner can do without help and what he or she can do with help [2]. However, Vygotsky [16] defined zone of proximal development as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers*[3].Vygotsky[16] conceived that ZPD is central to instructional enhancement and classroom change. [18] Submitted that teaching within the ZPD where the learners' comprehension is mediated and scaffolded by the teacher makes learning more meaningful, easier, manageable, effective and efficient. In the context of this study, the teaching of stoichiometry in the learners' zone of proximal development is viewed as one way of improving performance in this aspect of Physical Science.

However, apparent lack of zone of proximal development in the teaching of stoichiometry in secondary schools in the Zambezi region of Namibia has resulted in the learners' high failure rate in this concept. Stoichiometric skill is the core foundation in the teaching of reaction chemistry, and has also been regarded as a "fundamental tool in the chemical toolbox" [5]. The skill is very critical to the understanding of chemistry involving calculations of reacting masses during chemical reactions. Problems such as calculating moles of reacting masses, predicting theoretical and actual yield of a product formed, acid-base reactions problems and equilibrium, calculating gas volumes at standard temperature and pressure (s.t.p), percentage compositions of elements in a compound are among several questions learners come across during examination. Solving these empirical-based questions requires high degree of proficiency in stoichiometric skills. Considering the consistent rate of poor performance by learners in stoichiometry questions over the years, [6] submitted that learners are clearly not in their ZPD. Thus, effective learning can only take place if learners are provided with experiences within their ZPD. The Directorate of National Examination and Assessment, examiners report, [17]indicated that stoichiometry questions continue to post difficult challenges to learners during the final Namibia Senior Secondary Certificate (NSSC) ordinary level examination.

This problem is further compounded by Namibia having a large number of untrained science teachers and unskilled workers in the various fields of sciences [1] and this may be attributed to the impact of colonial master. Before the country got her independence in 1990, teachers were trained to teach for rote learning rather than knowledge with understanding [7]. This may adversely affect effective development of the learners' ZPD.

Thus, this study investigated the effect of the zone of proximal development on the performance of learners in stoichiometry in selected secondary schools in the Zambezi Region and recommendstrategies that could be applied to improve the teaching of the concept and hence, improving learners passing rate in stoichiometry questions during examinations.

2. Methodology

This study employed qualitative approaches. Qualitative research method was considered appropriate in order to obtain indepth information on the problem investigated.

2.1. Population of the study

The study population consists of all the Physical Science Grade 12 learners from four senior secondary schools. For the purpose of this study, the senior secondary schools are identified as School A, School B, School C and School D.

2.2 Sample of the Study

Table l: Distribution of the study participants

School	Participants	Total number of learners
School A	Grade12 learners	26
School B	Grade 12 learners	26
School C	Grade 12 learners	21
School D	Grade 12 learners	10
Total		83

2.3. Data collection

Data collection questionnaire of this study focused on learners’ knowledge of stoichiometry content, perceived factors affecting learner’s comprehension of stoichiometry, method of teaching stoichiometry concepts, and strategies put in place in the schools to aid learners performance in stoichiometry. The physical science teachers were also interviewed on these focal areas to assess their views on the problem being investigated.

2.4 Analysis of the data

The results obtained were presented as frequencies and relative frequencies of the responses in the three Linkert scale - agree, undecided, and disagree with the probing questions.

3. Results and Discussion

3.1 Learners’ knowledge of stoichiometry contents

Table 2 below presents the findings on the learners' knowledge of stoichiometry contents while Figure 1 presents the overall mean respondents on learners' knowledge of stoichiometry. The results in the table showed that an average of 29.25% of the learners who completed the questionnaires agreed that their knowledge of stoichiometry is sound enough to solve stoichiometry problems in Physical Science, 55.50% disagreed while 15.25% were undecided. On whether stoichiometry will be better understood if taught using the indigenous knowledge, 55.00% of the learners agreed while 38.50% disagreed and 6.50% of the participants were undecided. The high percentage of learners who wished that stoichiometry is taught in their indigenous knowledge to enhance their understanding of the concepts suggests two issues:

- Either the teachers' communication of stoichiometry concepts is not clearly understood by the learners and hence, create poor understanding, or
- The learners have very poor understanding of English being the official language of communication in the country.

These challenges, if obtainable may have serious implication for the learners' effort to yield good results in stoichiometry. In a related study, [8] used the concepts of mole, mass, volume and number of particles to find out the cause of the great difficulties encountered by secondary school learners in solving stoichiometry problems. They submitted that the difficulty in the resolution of problems was probably due to the use of the term mole and other unfamiliar terms, rather than the lack of understanding of the volume, mass and number of particles. According to Van der Poll & Van der Poll as cited in [10] when learners have to use a language that they are not proficient in, they are faced with the problem of content literacy and mastering of contents (both practical and theoretical). Thus, teachers in the study area could explore communicating certain stoichiometry concepts in more familiar terms that the learners can understand easily. In doing so however; care should be taken not to change the intended meaning of the concepts.

In the solving of stoichiometry questions, 54.75% agreed that they found it difficult to identify the reactant-product pair necessary to achieve the desired results. This is also a great concern in the study of stoichiometry because once a learner cannot identify the reactant-product pair in a given problem, getting the correct answer is no longer possible because the mathematics involved in the problem depends on first, identifying the correct reactant-product pair in terms which reactant in the stated problem yield the product and in what mole ratio. [9] noted that because mole is a concept devised by scientists to aid in chemical calculations, learners' misconceptions of it could hardly be regarded as intuitive problem but arise due to insufficient instruction or inappropriate teaching strategies. On whether the learners can identify reactant-reactant pair or product-product pair in a stoichiometry problem in which the solution depends on either the reactants only or the products only; it was observed that 52.00% of the participants indicated that it is very difficult to identify reactant-reactant pair relevant to the solution of a given problem while 33.00 % disagreed. Similarly, a higher percentage (46.75%) of the learners indicated that they also found it very difficult to identify product-product pair relevant to the solution of a given problem. These findings suggest that the learners may lack understanding of the basic principle of analysing words problems to identify related variables. This is evident in the response obtained when the participants were asked if they can interpret stoichiometry problem very well and plan the solution. A total of 56.25% of the participants agreed that they cannot interpret stoichiometry problem and plan the solution while 31% disagreed but 17.25% were undecided. Based on the examiners' reports which indicated a general poor understanding of stoichiometry by learners in the study area,there is need to carry out further diagnostic research to ascertain whether those who disagreed with the probing questions actually understand what they claimed to know.

Table 2: Learners knowledge of stoichiometry contents

Probing questions		A (%) Agreed	U (%) Undecided	D (%) Disagreed
1. Your knowledge of stoichiometry is sound enough to solve stoichiometry problems	Sch A	27	23	50
	Sch B	11	8	81
	Sch C	19	10	76
	Sch D	60	20	20
	Mean	**29.25**	**15.25**	**55.5**
2. Do you think stoichiometry concept will be better understood if taught using indigenous language	Sch A	46	8	46
	Sch B	61	8	31
	Sch C	29	10	57
	Sch D	80	0	20
	Mean	**55**	**6.50**	**38.5**
3. When given stoichiometry question, I always find it difficult to identify the reactant product pair	Sch A	47	27	23
	Sch B	51	8	39
	Sch C	72	0	24
	Sch D	40	20	40
	Mean	**54.75**	**13.75**	**31.5**
4. When given stoichiometry question, I always find it difficult to identify the reactant-reactant pair	Sch A	53	15	31
	Sch B	43	15	35
	Sch C	66	19	10
	Sch D	33	11	56
	Mean	**52**	**15.00**	**33**
5.]. When given stoichiometry question, I always find it difficult to identify the product-product pair	Sch A	40	27	23
	Sch B	39	15	43
	Sch C	58	5	34
	Sch D	33	22	44
	Mean	**46.75**	**17.25**	**36**
6. In stoichiometry questions, I always finds it difficult to interpret the information and plan solution.	Sch A	69	8	23
	Sch B	50	8	38
	Sch C	48	5	43
	Sch D	50	30	20
	Mean	**56.25**	**12.75**	**31**

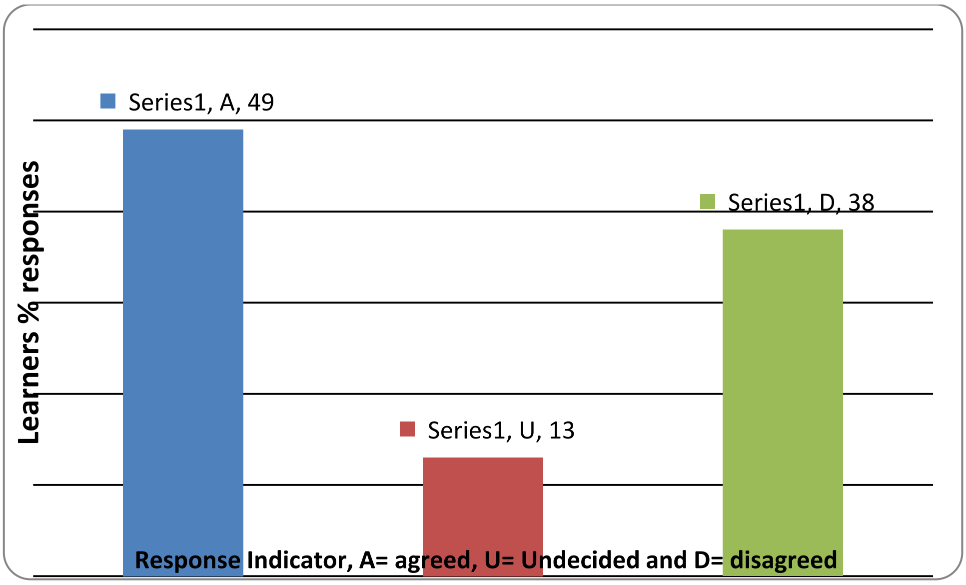

Figure 1: Overall mean respondents on learners' knowledge of stoichiometry

3.2 Perceived factors affecting learners' performance in stoichiometry

Table 3 presents the findings on the perceived factors affecting learners' performance in stoichiometry and figure 2 shows the overall means respondents. The results (table 3) showed that an average of 28.25% of the learners who completed the questionnaires agreed that the principles underlining stoichiometry is straight forward and understandable in order to solve stoichiometry problems, but 42.25% disagreed while 29.25% were undecided. The lack of proper understanding of the principles underlining stoichiometry by the participants became more obvious when only 28.75% of the learners agreed that they follow appropriate procedure in solving stoichiometry problem while 51.50% disagreed and 19.75% of the participants were undecided. The result also showed that only 18.25% of the participants agreed that they engaged in group work to solve stoichiometry problems while 75.00% disagreed and 6.75% were undecided. This suggests a lack of collaborative or peer-assisted learrning among the learners when solving stoichiometry problems. Peer learning has been recognised by educational researchers for its positive role in classroom-based learning ([11,12,13]). Peer learning is a form of teaching strategies that involve learners working together in pairs or small groups to accomplish a mutual educational goal or task ([14,15]). The lack of peer-assisted learrning among the learners as shown in the participants' responses could adversely affect their skills in solving stoichiometry. Peer learning is a very helpful approach to solving general academic problems as learners could easily discover useful tips through exchanging of ideas. This should particularly be encouraged in the study area as majority of the participants also viewed stoichiometry as mainly calculation concepts just like mathematics . However, the mathematics of stoichiometry follows from the logic of words problem which the learners can analyse and understand better through group discussion. The high percentage of the learners in the overall means respondent as seen in figure 2, disagreeing with factors affecting learners performance in stoichiometry suggest a negative attitude towards the concepts and this may certainly affect their learning of stoichiometry concepts. Thus, there is need to research on learners' perceptions about the stoichiometry.

Table 3: Perceived factors affecting learners' performance in stoichiometry

Probing questions		A (%) Agreed	U (%) Undecided	D (%) Disagreed
1. Are the principles underlining stoichiometry straight forward and understandable enough for you to solve problems in stoichiometry?	Sch A	33	27	50
	Sch B	16	31	50
	Sch C	24	19	57
	Sch D	50	40	10
	Mean	**28.25**	**29.25**	**42.5**
2. Do you think you always follow appropriate procedure in solving stoichiometry questions?	Sch A	16	15	69
	Sch B	16	19	65
	Sch C	33	5	62
	Sch D	50	40	10
	Mean	**28.75**	**19.75**	**51.50**
3. Do most learners in your school work in group to solve on stoichiometry questions?	Sch A	7	8	85
	Sch B	12	4	85
	Sch C	5	5	86
	Sch D	50	10	40
	Mean	**18.25**	**6.75**	**75**
4. Does your knowledge of stoichiometry concept assist you in understanding other calculations in chemistry?	Sch A	35	23	39
	Sch B	62	15	23
	Sch C	15	5	91
	Sch D	70	20	10
	Mean	**42.5**	**15.75**	**38.75**
5. Do you think mathematics concept is necessary to understand stoichiometry?	Sch A	84	8	8
	Sch B	69	12	15
	Sch C	52	29	19
	Sch D	90	0	10
	Mean	**74.75**	**12.25**	**13**

3.3 Strategies for improving performance in stoichiometry in the study area

Table 4 presents the findings on the strategies for improving performance in stoichiometry in the study area. The overall means of respondents on strategies for improving performance in stoichiometry is shown in figure 3.

The results showed that an average of 30% of the participants agreed on meeting their physical science teachers for assistance on stoichiometry problems, 11% undecided while 61% disagreed.

The high percentage of the learners which indicated not meeting their science teachers for assistance in solving stoichiometry problems suggest a negative attitude towards the concepts and this may certainly affect their view not only of stoichiometry but Physical Science as a whole.

Learners must be encouraged to see their subject teachers for special problems since often times; the teachers may not be able to accommodate all the different learning capabilities in the classroom.

When a student meets a teacher for one to one discussion, the teacher is bound to adjust to the individual level of the student to make the discussion learner-centred and this way, help the student to improve on his/her learning.

Table 4: Strategies for improving performance in stoichiometry

Probing questions		A (%) Agreed	U (%) Undecided	D (%) Disagreed
1. Do you meet your Physical Science teacher regularly for assistance in stoichiometry's related problems?	Sch A	27	19	50
	Sch B	23	12	61
	Sch C	43	0	57
	Sch D	60	10	30
	Mean	13	17.75	69.25
2. Do you attend tutorial class to enhance your understanding of stoichiometry and chemistry generally	Sch A	19	12	69
	Sch B	12	12	77
	Sch C	5	5	91
	Sch D	50	10	40
	Mean	31.5	9.75	68.75
3. Are you aware of the existence of any tutorial class that teaches stoichiometry and chemistry generally?	Sch A	19	19	61
	Sch B	8	12	77
	Sch C	5	10	81
	Sch D	20	30	50
	Mean	38.25	10.25	51.50
4. Should stoichiometry concept be removed from the syllabus	Sch A	46	4	50
	Sch B	43	11	46
	Sch C	38	0	57
	Sch D	20	10	70
	Mean	38	6.25	55.75

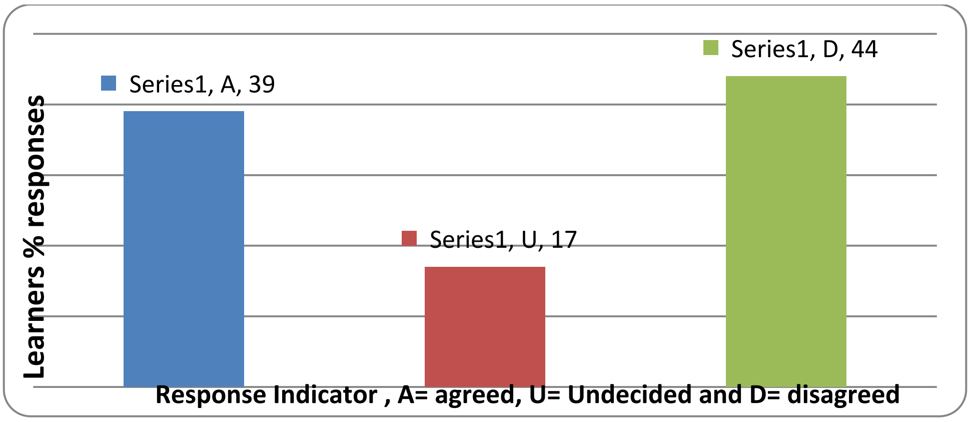

Figure 2: Overall mean respondents on perceived factors affecting learners' performance in stoichiometry

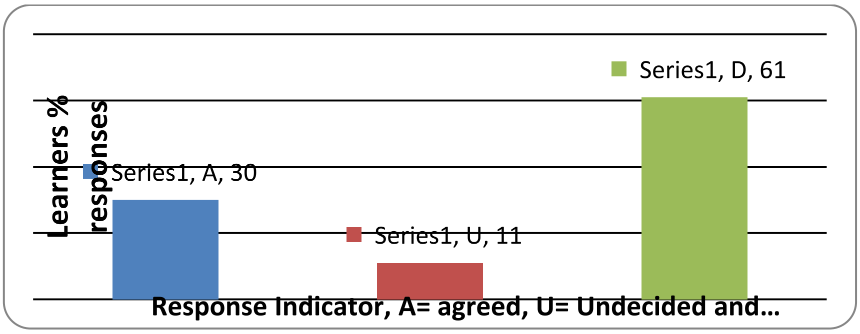

Figure 3: Overall mean respondents on strategies for improving performance in stoichiometry

4. Conclusion

The results of this study revealed that only 29.25% of the participants indicated that they have good knowledge of stoichiometry to solve related problems in the study area. On the perceived factors affecting learners' performance in stoichiometry, it was found that majority indicated lack of understanding of the principles underlying stoichiometry including the reactant-reactant pair and reactant-product pair needed to effectively plan solution to solve stoichiometry problems. More worrisome, is the lack of peer-assisted learning as indicated by the participants. Peer-assisted learning is a very helpful approach to solving general academic problems as learners could easily discover useful tips through exchanging of ideas. On the strategies for improving performance in stoichiometry, majority of the participants indicated that they do not always meet their science for help and are not aware of any tutorial class to help week learners in stoichiometry. This may lead to frustration and could make weak learners develop negative attitudes towards challenging concepts such as stoichiometry.

5. Recommendation

Considering the level of challenges Physical Science learners faced in the concepts of stoichiometry in the study area, there is urgent need for indepth diagnostic study in order to establish the specific challenges responsible for learners' poor performances in this component of Physical Science in the study area and devise mediation measures. Further research should also seek to determine the Physical Science teachers' content and pedagogical knowledge of stoichiometry in order to identify whether the teachers have the requisite content and pedagogical skills to teach stoichiometry effectively. There is also need to introduce tutorial classes that will provide extra teaching and support to learners as this will greatly help to shape the perceptions of weak learners about stoichiometry and other difficult academic concepts.

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