

Evaluating Secondary School Biology Teachers' Pedagogical Content Knowledge and Grade 10 Learners' Understanding of Respiration: Case of Chipata District, Zambia

Thumah Mapulanga^{1,*}, David Chituta²

¹Department of Natural Sciences, Gondar Day Secondary School, Chipata, Zambia

²Department of Mathematics and Science Education, School of Mathematics and Natural Sciences, The Copperbelt University, Kitwe, Zambia

*Corresponding author: thumahm@gmail.com

Received August 25, 2018; Revised October 17, 2018; Accepted November 01, 2018

Abstract This study evaluated Secondary School Biology Teachers' Pedagogical Content Knowledge (PCK) and Grade 10 learners' understanding of Respiration. This was on the premise that effective PCK could help to improve learners' conceptual understanding of respiration. However, there is a lack of empirical evidence backing the relationship between PCK and students' understanding of respiration concepts. A total of 11 teachers and 84 grade 10 learners were drawn from six schools in Chipata district, Zambia. The teachers' PCK was measured from lesson plans, lesson planning interviews and learners' questionnaires while students' understanding of respiration was measured using the Respiration Content Test. Quantitative data were analysed using SPSS by computing means, standard deviations, *t*-tests, and *F*-tests while lesson planning interviews were audio recorded and transcribed verbatim for further qualitative analysis. The results showed that the teachers demonstrated good pedagogical knowledge ($M = 3.30, SD = 1.31$) and content knowledge ($M = 3.32, SD = 1.00$) although their knowledge of students was poor ($M = 2.05, SD = 1.20$). The learners have a positive perception of teachers' PCK although males have a higher positive perception that teachers meet their learning needs ($M = 3.948, SD = 0.697$) than females ($M = 3.542, SD = 0.213$); $t(54) = 3.742, p < 0.001$. Learners' knowledge of respiration is good ($M = 61.81\%, SD = 37.74$) although they generally had difficulties answering questions of higher order demand. The findings imply that teachers of biology need to consider learners' prior knowledge and learning difficulties in their lessons in order to provide inclusive and equitable quality education. Policymakers and administrators should reinforce training programs aimed at enriching in-service teachers' PCK. Future studies need to show how specific teaching methods can be used to help students overcome their learning difficulties and misconceptions about respiration.

Keywords: *pedagogical knowledge, content knowledge, knowledge of students, respiration*

Cite This Article: Thumah Mapulanga, and David Chituta, "Evaluating Secondary School Biology Teachers' Pedagogical Content Knowledge and Grade 10 Learners' Understanding of Respiration: Case of Chipata District, Zambia." *American Journal of Educational Research*, vol. 6, no. 10 (2018): 1438-1444. doi: 10.12691/education-6-10-15.

1. Introduction

1.1. Background

Knowledge of biology plays a very important role in society as it has been used to solve various problems that have socio-scientific implications. For example, knowledge of biology has been used to solve problems of diseases affecting both livestock and humans, the problem of unwanted pregnancies and protection and general management of the environment.

Despite the importance of biological knowledge, the performance of students in biology at grade 12 in

Examinations Council of Zambia (ECZ) examinations has been perpetually poor. For instance, the students' mean scores in biology were; 22.6% in 2012, 24.9% in 2013 [1], 21.4% in 2014, 21.6% in 2015 [2], 24.1% in 2016 and 26.6% in 2017 [3]. In the 2013 and 2014 examinations respiration was one of the topics that were poorly scored [1]. These reports also indicate that the majority of students were unable to satisfactorily answer questions that require higher order thinking skills or descriptions. The above situation is an indication that students may not be understanding concepts in specific topics of biology. The students' poor performance in biology has been attributed to many factors including teacher-related factors. The teacher plays a critical role in transforming and communicating biology knowledge in order to

enhance students' conceptual understanding of biological concepts.

In view of the above, recent research has focused on the development of science teachers' knowledge base [4]. The teachers' knowledge base has been categorized into content knowledge, pedagogical knowledge, and knowledge of students. These three types of teachers' knowledge relate to Shulman's conceptualisation of Pedagogical Content Knowledge (PCK) [5]. PCK can thus be seen as the teachers' knowledge with which they assist students to learn meaningfully. Since PCK describes teachers' understanding of how to help students understand the subject-specific matter (content), promotion and evaluation of teachers' PCK are important for improving the learning process.

According to Shulman as cited in [6], producing an effective lesson requires three types of professional knowledge namely; content knowledge, pedagogical knowledge, and knowledge of students (PCK). It follows, therefore, that a lack of a well-developed teachers' PCK could account for the lack of understanding of biology among learners as it suggests that teachers are unable to make biology accessible to the learners. To be effective, science teachers must know how to best design and guide learning experiences that help diverse groups of students develop knowledge and understanding of the science concepts [7].

In the context of teaching biology, teachers need to be able to address students' learning needs in order for students to understand biology concepts being taught to them. This is because when teachers are aware of the needs of their students, they are able to think of ways of improving their practice so as to address the needs of their learners. It follows, therefore, that biology teachers need a well-developed and differentiated PCK for them to realise the importance of students' understanding of specific biology concepts such as 'respiration'. Respiration has been regarded as a difficult topic for students to learn because it is a complex biological process that involves integrating multiple concepts. Researchers agree that the understanding of respiration among students is weak [8] and that students hold misconceptions related to respiration [9]. Additionally, respiration is considered very abstract because the process occurs at the cellular level making it difficult for learners to learn the topic meaningfully. It is therefore important to evaluate the teaching and learning of respiration with respect to teachers' knowledge base (PCK).

Previous studies on PCK indicate that researchers have concentrated on the measurement of teachers' PCK [10], the practice of PCK [5] and the development of teachers' PCK [11]. However, there is little research related to PCK and students' understanding [12]. For example, there is little research concerning teachers' PCK and how it affects students' learning of life sciences [13]; research on PCK is rare in biology education [4] and there is a lack of empirical studies on the relationship between teachers' PCK and students' understanding of science concepts [12]. This shows a knowledge gap that requires to be closed-up especially with respect to the topic 'respiration' which has proved to be a challenging topic for most learners.

1.2. Problem Statement

There exists a close relationship between teachers' knowledge base (PCK) and learners' understanding of

concepts learned. However, little research has been conducted on how the two are linked especially in the context of the teaching and learning of respiration. Additionally, aerobic respiration has been regarded as a difficult topic for students to learn because of its complex nature of integrating multiple concepts, and understanding of respiration among students is weak [8]. If not addressed, understanding of respiration may persistently be low and thus contribute to the continued learners' poor performance in biology examinations. In Zambia, respiration is taught from primary through to university level. At the secondary level, the topic of respiration features in grade 10 in the *Zambian Biology High School Syllabus for Grades 10 to 12*. In this topic (respiration), learners are expected to grasp basic concepts such as gaseous exchange surfaces, types of tissue respiration, production of adenosine triphosphate, production of carbon dioxide, importance and application of respiration [14]. The study focused on biology teachers' PCK in teaching these basic respiratory concepts. Therefore, this study evaluated secondary school biology teachers' PCK as it relates to the teaching of respiration and grade 10 learners' understanding of respiration.

1.3. Purpose of Study

The purpose of the study was to 'Evaluate Secondary School Biology Teachers' PCK and Grade 10 learners' Understanding of Respiration'.

1.4. Research Questions

The study sought to answer the following research questions;

1. What components of PCK do Secondary School Biology Teachers demonstrate during respiration lessons' planning and teaching?
2. What are the Grade 10 learners' perceptions of their biology teachers' PCK related to the teaching of respiration?
3. What knowledge level of respiration do Grade 10 learners demonstrate after being taught?

1.5. Theoretical Framework

The study used Pedagogical Content Knowledge (PCK) as a theoretical framework that consisted of teachers' (respiration) content knowledge, pedagogical knowledge and knowledge of students. The use of PCK as a theoretical framework is supported by Gess-Newsome and N. Lederman [7]. It was presumed that PCK can positively influence teachers' practice and therefore, students' understanding of respiration. The three components of PCK were assumed to individually and collectively contribute to the learners' understanding and hence, improved performance in respiration. It was further assumed that PCK can be measured from four (4) aspects as illustrated in [Figure 1](#).

1.6. Significance of the Study

The findings of this study are useful to teachers, policymakers, institutions of teacher education, and researchers. Specifically, the study has the potential to;

1. Define aspects of teacher expertise in science teaching that can be used to enhance Continuous professional development (CPD) programs related to PCK.
2. Enlighten teachers on the role of PCK in learners' understanding of respiration.
3. Expose teachers to the learners' learning difficulties and misconceptions about respiration, and
4. Expose teachers and learners to some ways of overcoming the learning difficulties and correcting learners' misconceptions.

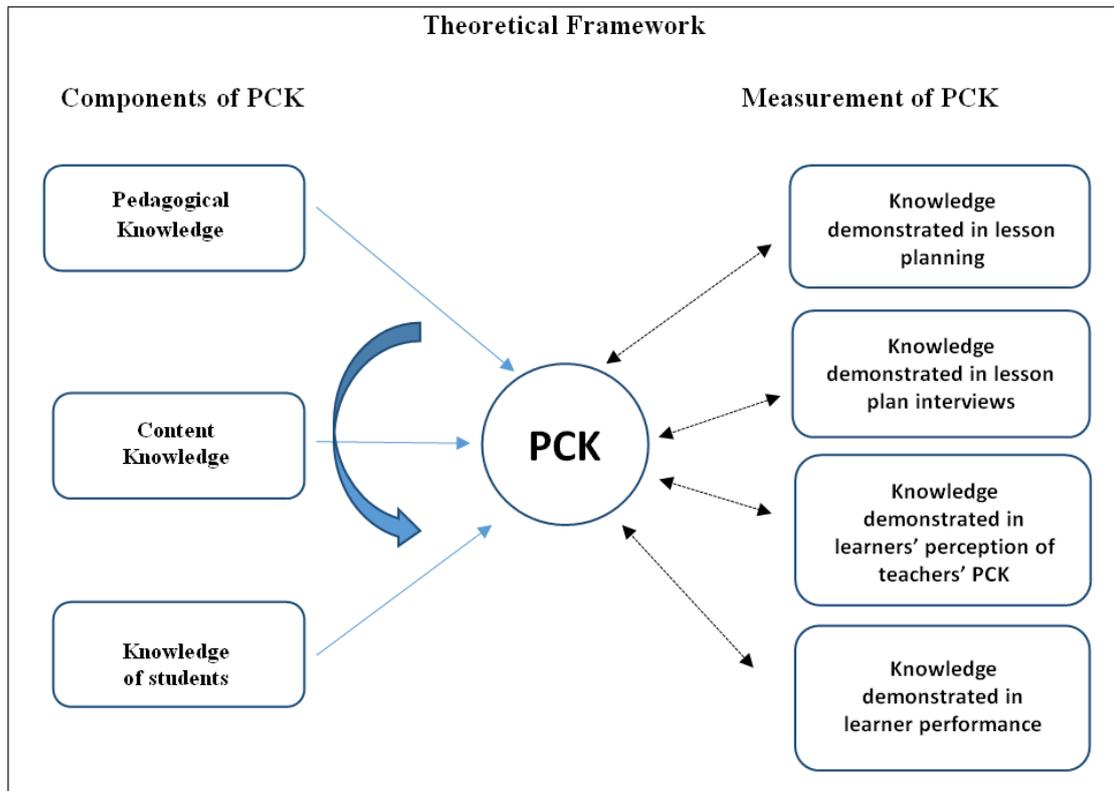


Figure 1. Components and Measurement of Pedagogical Content Knowledge (PCK)

2. Methodology

2.1. Research Design

The study adopted a mixed methods research design to collect both quantitative and qualitative data from participant teachers and learners. The collection of data was done between September and December 2017.

2.2. Research Participants

All Secondary School Biology teachers at the six pre-selected schools formed the target population while the sample comprised 11 biology teachers (6 males, 5 females) who were purposively sampled and 84 grade 10 learners (46 males, 38 females) who were randomly selected from the six schools.

2.3. Data Collection Instruments

The Lesson plan evaluation schedule, Learners' perception of teachers' PCK questionnaire and Learners' Respiration content test were developed for collecting quantitative data while a Lesson plan interview guide was developed for collecting qualitative data needed to answer the research questions. All the instruments were peer and expert-reviewed to ensure validity and reliability. The instruments were administered to the respective participants in their school setting.

2.4. Procedures

Specific procedures that were used to collect the data needed to answer the research questions are described below.

2.4.1. Components of PCK that Secondary School Biology Teachers Demonstrated During Respiration Lessons' Planning and Teaching

1. The teachers were each asked to prepare an 80 minutes' lesson for a grade 10 class on the topic 'Respiration'. Therefore, 11 lesson plans were collected for analysis of teachers' PCK, a 5-point Likert scale lesson plan evaluation schedule (LPES) was used to analyse the lesson plans.
2. Face to face interviews were conducted with 10 teachers using an interview guide adapted from [15]. Before the interview, each teacher was taken through the interview questions so that they understood the questions' demands. The interviews were conducted in each teachers' school context and lasted for 10 – 19 minutes. All the interviews were audio recorded and transcribed verbatim for further analysis.

2.4.2. Learners' Perceptions of Their Biology Teachers' PCK

The learners' perceptions of their teachers' PCK were measured using a 5-point Likert scale questionnaire administered to 84 grade 10 learners. The purposes of the

study and each of the questionnaire items were explained to the learners and the researcher was available to make clarifications where necessary.

2.4.3. Grade 10 Learners' Understanding of Respiration

The grade 10 learners' understanding of respiration was measured using a respiration content test (RCT).

2.5. Data Analysis

The quantitative data that were collected using the Questionnaires, Lesson plan evaluation schedules and the Respiration content test were analysed using the Statistical Package for the Social Sciences (SPSS) to generate descriptive statistics (means and standard deviations), and inferential statistics (*t*-tests and *F* – tests). The face to face interviews were audio recorded, transcribed verbatim and analysed by coming up with themes and trends related to pedagogical content knowledge. The data were then triangulated so as to gain an in-depth understanding of emerging themes.

3. Findings

3.1. Components of PCK Demonstrated by Teachers

The teachers demonstrated pedagogical knowledge, content knowledge and knowledge of students' components of PCK. The mean scores for each component are presented in Table 1.

Table 1. Components of PCK Demonstrated by Teachers

Component of PCK	<i>M</i>	<i>SD</i>
1. Pedagogical Knowledge	3.30	1.31
2. Content Knowledge	3.32	1.00
3. Knowledge of Students	2.05	1.20

Interpretation scale: 0 = Undecided; 1 = very poor; 2 = poor; 3 = good; 4 = Very good.

3.1.1. Teachers' Gender and Their PCK Scores

The teachers' PCK did not significantly differ by their gender, for Pedagogical Knowledge [males ($M = 3.29$, $SD = 0.69$) and females ($M = 3.31$, $SD = 0.41$), $t(9) = 0.060$, $p = 0.953$], for Content Knowledge [males ($M = 3.39$, $SD = 0.57$) and females ($M = 3.25$, $SD = 0.15$), $t(6) = 0.515$, $p = 0.625$]. For content knowledge, the Levene's test indicated unequal variances ($F = 7.718$, $p = 0.021$), so degrees of freedom were adjusted from 9 to 6.

Similarly, the teachers' Knowledge of students was not significantly different [males ($M = 1.97$, $SD = 0.91$) and females ($M = 2.16$, $SD = 0.36$), $t(7) = 0.475$, $p = 0.650$]. Levene's test indicated unequal variances ($F = 6.200$, $p = 0.034$), so degrees of freedom were adjusted from 9 to 7.

3.1.2. Teachers' Years Served and Their PCK Scores

The study found that six teachers had served for 1 – 5 years, three teachers had taught for 6 – 10 years and two teachers had taught for more than 11 years. However, teachers' PCK scores on the components of PCK did not significantly differ with the number of years served; for

Pedagogical Knowledge, $F(2,8) = 2.555$, $p = 0.139$; for Content Knowledge $F(2,8) = 0.274$, $p = 0.767$; and for Knowledge of students, $F(2,8) = 0.451$, $p = 0.652$.

3.1.3. Teachers' Qualifications and Their PCK Scores

The teachers demonstrated good pedagogical knowledge ($M = 3.30$, $SD = 0.55$) and content knowledge ($M = 3.32$, $SD = 0.42$) but they demonstrated poor knowledge of students ($M = 2.05$, $SD = 0.69$) except for the certificate holder ($M = 3.4$). However, Analysis of Variance (ANOVA) indicated that teachers' qualifications did not significantly influence either of the components of PCK, for Pedagogical Knowledge [$F(2,8) = 0.48$, $p = 0.64$], Content Knowledge [$F(2,8) = 0.18$, $p = 0.84$], and Knowledge of students [$F(2,8) = 2.91$, $p = 0.11$]. However, degree holders scored slightly lower ($M = 3.09$, $SD = 0.39$) on pedagogical knowledge than the certificate holder ($M = 3.64$) and diploma holders ($M = 3.38$, $SD = 0.67$).

3.2. Teachers' Pedagogical Knowledge

3.2.1. Factors Considered When Designing Lessons

The factors that teachers consider as they design their lesson plans include; *the use of teaching aids, schemes of work, learning expectations, subtopic, objectives, class enrolment and gender of learners.*

3.2.2. Teaching Methods

Seven teachers considered using *lecture-discussions*, three teachers had considered using *experiments* while only one teacher had considered using *a group activity* in their lessons. However, only three teachers had considered using an alternative teaching method and thus arranging the lesson in a different way.

3.2.3. Source of Knowledge of Teaching Methods

The teachers' main sources of knowledge of teaching methods were; *Formal learning (university and college), CPD meetings, Self-study, and Interactions with colleagues.* However, the most frequently mentioned source was formal learning.

3.2.4. Teaching Aids

The most frequently used teaching aid was the chart, followed by Experimental apparatus and lastly Textbooks. According to the teachers, they chose to use teaching aids because they *enhance learning, summarise the process of respiration and are self-explanatory.*

3.3. Teachers' Content Knowledge

The 10 teachers that were interviewed all agreed that they had taught respiration before and therefore, they had experiences from which to learn and develop better respiration lessons.

3.3.1. Teachers' Perception of Their Knowledge of Respiration

All the teachers agreed that they had good knowledge of respiration with four saying that they knew the topic very well compared to five who said they knew it well.

Additionally, all the teachers indicated that they had learned respiration at *tertiary level*, three teachers included the *secondary school*, one teacher included *self-study (research)* while two teachers included *continuous professional development (CPD)* activities as sources of their knowledge of respiration.

3.3.2. Important Respiratory Concepts That Learners Are Expected To Know

Eight teachers stated the concepts they intended the learners to know while two teachers did not provide evidence of any concepts they intended the learners to know. Furthermore, only seven teachers provided evidence of extra concepts of respiration that were beyond the grade 10 learners' syllabus requirement. Table 2 shows the important respiration concepts that learners are expected to know.

Table 2. Important concepts for learners to know

1. Importance of oxygen around us
2. Types of respiration
3. Domestic and industrial application of respiration
4. Respiration yields energy in both plants and animals

3.4. Teachers' Knowledge of Students

3.4.1. Teachers' Anticipation of Learners' Prior Knowledge

The majority (seven) of the teachers expected students to have prior knowledge of respiration while three teachers did not. The teachers who expected students to have prior knowledge of respiration explained that students may have encountered the topic at primary and at Junior secondary levels.

3.4.2. Teachers' Anticipation of Learners' Learning Difficulties

Half (five) of the teachers indicated that students might have learning difficulties while the other half said they did not expect students to have any learning difficulties. For example, two teachers said learners fail to differentiate between respiration and breathing.

3.4.3. Teachers' Anticipation of Learners' Misconceptions in Respiration

Over half (six) of the teachers stated that they anticipated students' misconceptions about respiration while four of them did not provide evidence of misconceptions anticipated from the learners. The highest anticipated misconception was that '*respiration is the same as breathing*', followed by the misconception that '*respiration only occurs at night in plants*', and the least anticipated misconception was that '*respiration only occurs in animals*'. The most frequently mentioned approach for helping learners to overcome their misconceptions was '*the use of explanations*' followed by '*use of experiments*'.

3.5. Learners' Perception of Teachers' Pedagogical Content Knowledge (PCK)

The learners' perception of their teachers' PCK was good for all the three components of PCK as shown in Table 3.

Table 3. Learners' Perception of Teachers' PCK

Component of PCK	<i>M</i>	<i>SD</i>
1. Pedagogical Knowledge	3.95	0.92
2. Content Knowledge	3.83	1.08
3. Knowledge of Students	3.76	1.40

Interpretation scale: 0 = Undecided; 1 = very poor; 2 = poor; 3 = good; 4 = Very good.

3.5.1. Teachers' Pedagogical Knowledge

The learners' perceptions of teachers' Pedagogical knowledge were not significantly different by gender, for males ($M = 3.96$, $SD = 0.43$) and females ($M = 3.94$, $SD = 0.39$), $t(82) = 0.165$, $p = 0.870$.

3.5.2. Teachers' Content Knowledge

With regards to content knowledge, females had higher positive perceptions of their teachers' Content knowledge ($M = 3.94$, $SD = 0.37$) than males ($M = 3.73$, $SD = 0.46$); $t(81) = 2.291$, $p = 0.025$. Levene's test indicated unequal variances ($F = 5.976$, $p = 0.017$), so degrees of freedom were adjusted from 82 to 81.

3.5.3. Teachers' Knowledge of Students

Male learners had higher positive perceptions of their teachers' Knowledge of students ($M = 3.95$, $SD = 0.69$) than females ($M = 3.54$, $SD = 0.21$); $t(54) = 3.742$, $p < 0.001$. Levene's test indicated unequal variances ($F = 38.208$, $p < 0.001$), so degrees of freedom were adjusted from 82 to 54.

3.6. Grade 10 Learners' Understanding of Respiration

The learners' understanding of respiration is relatively good ($M = 61.81\%$, $SD = 37.74$) as can be seen in Table 4. However, an independent samples t-test indicated that the learners' understanding of respiration did not significantly differ by gender, for females ($M = 70.83$, $SD = 23.27$) and males ($M = 57.29$, $SD = 13.55$), $t(82) = 1.58$, $p = 0.135$.

Table 4. Learners' understanding of Respiration

Question/Concept	<i>M (%)</i>	<i>SD</i>
1. Define respiration	50.00	51.45
2. State the types of tissue respiration	100.00	0.00
3. Name the part of the cell where respiration occurs	50.00	51.45
4. Do green plants respire?	100.00	0.00
5. When do green plants respire?	61.11	50.16
6. State the products of alcoholic fermentation	61.11	50.16
7. Explain the importance of respiration	33.33	48.51
8. What is respiration all about?	38.89	50.16
Average	61.81	37.74

4. Discussion of Findings

4.1. Components of PCK Demonstrated by Secondary School Biology Teachers

The teachers demonstrated Pedagogical Knowledge, Content Knowledge and Knowledge of Students as

components of PCK. These findings are supported by Mansor et al., who found that content knowledge, pedagogical knowledge, and knowledge about students were among the components of teachers' PCK that contributed to the students' understanding of respiration [12].

4.1.1. Teachers' Pedagogical Knowledge

The findings that just over half of the teachers had good pedagogical knowledge have implications for the teaching and learning process and the performance of learners. It might mean that nearly half of the teachers do not make appropriate pedagogical decisions that might enhance students' understanding of concepts as doing so depends on the quality of the teachers' pedagogical knowledge [16]. The good scores by Diploma and certificate holders could be attributed to the fact that these were trained teachers while the degree holders' poor scores could be attributed to the fact that majority of them were untrained teachers, but holders of bachelor of science degrees. Therefore, there is an urgent need to empower serving untrained teachers with pedagogical related knowledge and skills either through CPD meetings or training at institutions of higher learning.

The finding that the most frequently used teaching method was the lecture-discussion agrees with other findings [17]. It can thus be deduced that the way biology is taught could be one of the factors that affect the performance of students in biology examinations. However, teachers need to make informed and thoughtful use of various teaching methods, in ways that can influence students' understanding of scientific ideas [5].

Teachers chose to use teaching aids to give more concrete meaning to words, show explicit connections and relationships among ideas, provide memorable images in the minds of learners and make lesson content more interesting to learners [18]. However, they need to become more innovative and use other teaching aids in addition to the chart. Where the chart is used, it must be used appropriately.

4.1.2. Teachers' Content Knowledge

Generally, the teachers demonstrated good content knowledge regardless of their qualifications. The teachers also demonstrated a good amount of knowledge of respiration that was beyond the level of learners, a result similar to what was found in [12]. Although teachers perceived themselves to know the topic of respiration well, they seem to be relying more on knowledge acquired from formal training and are learning less while in the field. However, teachers need further in-service learning of content and pedagogy since new knowledge emerging from research needs to be accessed, processed and evaluated, and transformed into knowledge for practice [16].

4.1.3. Teachers' Knowledge of Students

The teachers demonstrated poor knowledge of students regardless of their years of service and qualification, a result similar to findings in [6]. A lack of this component of PCK has serious implications for planning and teaching because successful science teachers plan their lessons around what they have learned about their students [5]. Therefore, teachers need to consider the students' prior knowledge of respiration for effective lesson delivery as lack of this knowledge may inhibit their ability to design

effective lessons that may result in conceptual change, enhanced understanding and hence improved performance in biology.

4.2. Learners' Perceptions of Their Biology Teachers' PCK

The learners perceived their teachers to have very good Pedagogical knowledge, Content knowledge and Knowledge of students. The students' perceptions of their teachers' pedagogical knowledge and content knowledge were similar to the results from the lesson evaluation schedule except for the knowledge of students. However, learners' perceptions differed from the outcome of the lesson plan evaluation which showed that the teachers did not demonstrate good knowledge of students. The differences suggest that grade 10 learners may not be in a position to accurately describe what constitutes good learning and teaching. This study found that a fairly good learner performance corresponded to learners' positive perceptions of teachers' PCK contrary to findings in [19]. The finding that males have a higher positive perception that teachers meet their learning needs compared to girls has implications for the provision of inclusive and equitable access to quality education in light of Sustainable Development Goal (SDG) No. 4 as it may suggest that teachers are not providing equitable education.

4.3. Grade 10 Learners' Understanding of Respiration

The findings indicate that the knowledge level (understanding) of respiration demonstrated by learners is generally good. The learners demonstrated good knowledge of low order items that required a recall. However, they did not demonstrate good knowledge of respiration where the items required them to express the answer in an explanatory manner. These findings suggest that understanding of respiration among students is weak and that students hold a number of misconceptions about the respiration and are similar to findings in [8]. However, the learners' knowledge level of respiration can be improved by focusing on the knowledge of students and promoting the use of appropriate teaching methods that put the learner at the centre of the learning process. Teachers need to begin focusing not only on teaching content matter but also on helping learners acquire values and skills of high order such as analysis, comprehension, evaluation, and communication skills that are necessary to demonstrate an understanding of learned concepts.

5. Conclusions and Recommendations

In conclusion, this study has evaluated secondary school teachers' PCK and grade 10 learners' understanding of respiration. PCK was conceptualised as comprising of Pedagogical knowledge, Content knowledge and Knowledge of students. A mixed methods research design was adopted in order to analyse the knowledge that teachers draw in planning and teaching respiration lessons. The results show that biology teachers demonstrate pedagogical knowledge, content knowledge and knowledge

of students to varying degrees. The results also showed that teachers too often utilise the lecture-discussion approach, which is a passive and teacher-centred approach of transmitting knowledge without much consideration of the learners. However, teachers need to develop effective topic-specific and discipline level of PCK in biology and must be able to integrate the components of PCK as they plan and teach. Additionally, teachers need to be aware of the importance of the values and skills (outlined in the Biology syllabus) that they need to help learners develop in order for them to be able to comprehend the content more meaningfully.

Classroom implications of the results include the need for teachers to learn about the learners' misconceptions and learning difficulties in order to assist learners to find meaning in the learning of biology. Further, teachers need to be more reflective in their practice by interrogating the approaches and materials used in the lessons and the reasons behind such decisions. Teachers also need to pay attention to the knowledge of students in order to ensure the provision of inclusive and equitable quality education to all learners in pursuit of Sustainable development goal number 4 (SDG4).

For teacher education, the findings suggest the need to begin focusing on approaches that enable the majority of teachers to move beyond simply 'transmission' of knowledge to much more active and stimulating learner-centered teaching approaches. Further, the 'knowledge of students' component of PCK should be given more attention in biology teacher education programs. Implications for Policymakers and administrators include the need to intensify in-service training programs (CPD meetings) to help in-service teachers enhance specific components of PCK, which would, in turn, improve students' understanding.

Future studies need to show how specific teaching methods can be used to help students overcome their learning difficulties and misconceptions about respiration.

Note

This article reports some of the main findings of a study that was submitted to the Copperbelt University in partial fulfillment for the award of a Master of Science Degree in Biology Education. Submitted in July 2018.

References

- [1] Examinations Council of Zambia, "Examinations Performance Review," Examinations Council of Zambia, Lusaka, 2014.

- [2] Examinations Council of Zambia, "Examinations Performance Review," Examinations Council of Zambia, Lusaka, 2016.
- [3] Examinations Council of Zambia, "Examinations Performance Review," Examinations Council of Zambia, Lusaka, 2018.
- [4] V. Kind, "Pedagogical content knowledge in science education: Perspectives and potential for progress," *Studies in Science Education*, vol. 45, no. 2, pp. 169-204, 2009.
- [5] J. J. Loughran, P. Mulhall and A. Berry, *Understanding and Developing Science Teachers' Pedagogical Content Knowledge*, Rotterdam: Sen Publishers, 2006.
- [6] S. Chapoo, K. Thathong and L. Halim, "Biology Teachers' Pedagogical Content Knowledge in Thailand: Understanding and practice.," in *5th World Conference on Educational Sciences*, 2013.
- [7] J. Gess-Newsome and N. Lederman, *Examining pedagogical content knowledge*, Dordrecht, Netherlands: Kluwer Academic, 2001, pp. 95-132.
- [8] S. Kose, "Diagnosing student misconceptions using drawing as a research method," *World Applied Science Journal*, vol. 3, pp. 283-293, 2008.
- [9] O. Cakir, O. Geban, and N. Yuruk, "Effectiveness of conceptual change text-oriented instruction on students' understanding of cellular respiration concepts," *Biochem Mol Biol Edu*, vol. 30, no. 4, pp. 239-243, 2002.
- [10] M. Juttner, W. Boone, S. Park and B. J. Neuhaus, "Development and use of a test instrument to measure biology teachers' content knowledge (CK) and pedagogical knowledge (PCK)," *Education, Assessment, Evaluation and Accountability*, pp. 45-67, 2012.
- [11] W. Purwianongsih, E. Muthmainnah, and T. Hidayat, "Genetic Pedagogical Content Knowledge (PCK). Ability Profile of Prospective Biology Teacher," *J. Phys.: Conf. Ser.* 812012087, 2017.
- [12] M. Mansor, L. Halim and K. Osman, "Teachers' knowledge that promotes students' conceptual understanding," *Procedia Social and Behavioral Sciences*, vol. 9, no. 2010, pp. 1835-1839, 2010.
- [13] M. Kapyala, J. P. Heikkinen and T. Asunta, "Influence of Content Knowledge on Pedagogical Content Knowledge: The case of teaching photosynthesis and plant growth," *International Journal of Science Education*, vol. 31, no. 10, pp. 1395-1415, 2008.
- [14] MESVTEE., *Biology 5090 Syllabus: Grade 10-12*, Lusaka: CDC, 2013.
- [15] P. Friedrichsen, S. Abell, E. Pareja, P. Brown, D. Lankford and M. Volkman, "Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program.," *Journal of Research in Science Teaching*, vol. 46, no. 4, pp. 357-383, 2009.
- [16] S. Guerriero, *Pedagogical Knowledge and the Changing Nature of the Teaching Profession.*, Paris: OECD Publishing, 2017.
- [17] I. Weiss, E. Banilower, K. McMahon and P. Smith, "Report of the 2000 survey of science and mathematics education," Horizon Research Inc., Chapel Hill, 2001.
- [18] B. Joyce, M. Weil and E. Calhoun, *Models of Teaching*, Boston: Allyn and Bacon, 2000.
- [19] M. R. Kozub, "Student Evaluations of Faculty: Concerns and Possible Solutions," *Journal of College Teaching and Learning*, vol. 5, no. 11, 2008.