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Teachers' Perceived Enacted Pedagogical Content Knowledge in Biology at Selected Secondary Schools in Lusaka

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Abstract. The pedagogical content knowledge (PCK) of teachers influences students' achievement of the learning outcomes. This study examined teachers' perceived enactment of PCK in biology. The quantitative survey design was adopted by using a Likert-scale questionnaire consisting of six components of PCK, namely curricular saliency, students' prior knowledge, what makes the subject easy or difficult, representations, conceptual teaching strategies, and assessment. Data on teachers' perceived enacted PCK (ePCK) were collected from 54 biology teachers selected from 14 secondary schools in three districts of Lusaka province. The data were analyzed by computing descriptive and inferential statistics using Statistical Package for the Social Sciences (SPSS) software. The findings revealed that: (a) respondents' perceived ePCK was high (M = 4.29, SD = .37), (b) respondents' perceived ePCK was not influenced by gender, teaching experience, and type of school, (c) respondents' perceived ePCK was influenced by their academic qualifications, (d) the component students' prior knowledge and misconceptions was the most enacted component, and (e) the component what makes the subject easy or difficult was the least enacted component. The results highlight areas in teachers' PCK that require enhancement. The study recommends using teacher professional development to enhance teachers' ePCK in the component what makes the subject easy or difficult to understand. Further research may use larger samples and more data sources to increase the validity of the findings.

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1. Introduction

Developing countries are faced with a multitude of educational problems, including inadequate qualified teachers, which affect the quality of teaching and learning (Al-Ansi, 2017). Teachers play an important role in the learning process (Al-Ansi, 2017), as predictors of students' academic achievement. As such, teacher professional knowledge has attracted the attention of education researchers for some time. One type of teacher professional knowledge is the ability of the teacher to adapt subject matter knowledge and make it understandable to students of all academic levels. Shulman (1986) referred to this knowledge as the teacher's pedagogical content knowledge (PCK). Since teachers' PCK has a significant role in achieving students' learning outcomes in science subjects, many researchers have investigated the matter (Behling et al., 2022; Chan et al., 2019; Gess-Newsome et al., 2019; Park et al., 2020).

Researchers have used various approaches to measure teachers' PCK, such as interviews with teachers (Mapulanga et al., 2022; Suh & Park, 2017), analysis of teachers' and students' written scripts (document analysis) (Park & Oliver, 2008), lesson observations (Mthethwa-Kunene et al., 2015), teacher surveys (Schmelzing et al., 2013), and student surveys (Halim et al., 2014; Uner & Akkus, 2019). Others, such as Maseko and Khoza (2021), have used a combination of questionnaires, interviews, and classroom observation to explore teacher professional knowledge.

Shulman (1986) postulated that teacher professional knowledge comprises the combination of content (knowing what to teach) and pedagogy (knowing how to teach) and referred to it as PCK. PCK constitutes the knowledge used by teachers to transform knowledge in their subject areas, such as biology, into forms that students can understand regardless of their background. Veal and Makinster (1999) created a generic taxonomy for PCK, categorising PCK into general PCK for disciplines (e.g., science), domains (e.g., biology), and topics (e.g., respiration). In other words, discipline PCK involves, for example, PCK in the science discipline, whereas domain PCK, then, involves PCK in science subjects, such as biology. Topic-specific PCK (TSPCK) is the PCK used to teach specific topics in a subject, for example respiration. Aside from Shulman's model, multiple other models have been developed to describe teachers' PCK. These include Magnusson et al.'s (1999) model, the Pentagon Model (Park & Oliver, 2008), the Consensus Model (Gess-Newsome, 2015), the Topic-Specific Model (Mavhunga & Rollnick, 2013), and the Revised Consensus Model (Carlson et al., 2019). What is common among these and other models is the recognition that content knowledge needs to be transformed through some components of PCK.

Mavhunga and Rollnick's (2013) model was developed to describe TSPCK. The current study applied the TSPCK components to describe the PCK of teachers in biology. Furthermore, the current study included an additional component,

knowledge of assessment, so that six components of teachers' PCK were evaluated, as defined below (Magnusson et al., 1999; Mapulanga et al., 2022):

a. *Knowledge of assessment* [ASS] – the understanding of the concepts that must be measured, as well as knowledge of the techniques for measuring learning.
b. *Curricular saliency* [CS] – the ability of a teacher to pick and sequence crucial concepts for studying biology.
c. *What makes the subject easy or difficult to understand* [WD] – the understanding of concepts that require special attention while teaching biological concepts that students typically find difficult to grasp.
d. *Students' prior knowledge and misconceptions* [SPK] – the knowledge of what students already know from either personal experiences or prior teaching or both. It includes both alternative and correct conceptions.
e. *Representations and analogies* [RP] – the understanding of methods (e.g., diagrams, demonstrations, analogies, and models) for depicting biological topics in ways that aid in the conceptual growth of ideas.
f. *Conceptual teaching strategies* [CTS] – understanding of strategies for teaching specific topics, including competence and knowledge and effective connections of other PCK components.

2. Literature Review

This section presents an overview of reviewed studies related to teacher professional knowledge – or PCK. Many studies have been conducted to investigate the perceptions, views, or self-efficacy beliefs of pre-service and in-service teachers about aspects of their professional knowledge, most of which are aspects of the PCK domain. For example, Choy et al. (2013) examined the perceptions of early-career teachers in Singapore regarding their pedagogical knowledge related to lesson planning, classroom management, and instructional strategies. They used a survey questionnaire and found that teachers' perceptions increased significantly with experience. Kilic (2015) also used a questionnaire to establish the degree of pre-service teachers' perceptions of teacher knowledge. It was concluded that the perceptions of pre-service teachers about their teacher knowledge were high.

Mäkelä et al. (2019) investigated the perceptions of Finnish teachers about their PCK in higher education using teacher interviews with seven teachers. The findings indicated that teachers used diverse teaching methods and had positive attitudes towards educational technology. In a study related to teachers' PCK levels, Park et al. (2020) investigated the proxy indicators of the quality of teachers that best predicted their level of PCK. The sample comprised 166 secondary science teachers from South Korea and the United States. They found that the correlation between gender, years of service, and teachers' PCK was not significant. They also found that high school teaching and biology qualifications predicted teachers' PCK the best. However, the results showed that teachers had trouble connecting their understanding of students' comprehension with their use of teaching strategies. Zolkoski et al. (2020) investigated the perceptions of teachers regarding the knowledge and resources required to encourage emotional and social learning in rural classes. The results indicated that teachers had positive

perceptions to develop their abilities and knowledge to teach different students and to improve self-management.

Researchers have thus used surveys and interviews to describe teachers' professional knowledge or some aspects of it. Nonetheless, there is a shortage of research on teachers' perceived enacted PCK (ePCK) in biology. Furthermore, many studies either investigated teachers' actual enactment of components of technological pedagogical content knowledge (TPACK) or some components of PCK. The current study sought to contribute to closing this knowledge gap by exploring secondary school teachers' perceived ePCK in biology. Teachers' perceived PCK enactment is correlated with their actions in and outside the classroom. Teachers' perceptions may influence their decisions on the content (what to teach) and pedagogy (how to teach). In other words, teachers' perceptions of their ePCK may influence their choices related to instructional strategies, representations, content, examples, and assessment activities that they use during lessons. As Carlson et al. (2019) asserted, teachers' personal beliefs and attitudes towards teaching amplify their PCK and, hence, understanding how they perceive their ePCK is important. Consequently, it is vital to measure teachers' perceived ePCK in biology to understand how they employ their PCK in teaching and learning.

Examining the quality of teachers' PCK is a real concern in the education systems of many countries, as it is deemed to be a relevant and vital process for both the teachers' professional growth and educational advancement. However, there is a paucity of data on secondary school science teachers' perceived ePCK in Zambia, where the current study was conducted. There is also a lack of quantitative research on teachers' perceived enactment of PCK in biology. The current study investigated biology teachers' perceived ePCK at the domain (biology) level since this is where teachers borrow the TSPCK required to teach particular biology topics (Veal & Makinster, 1999). Therefore, the current study sought to assess biology teachers' perceived ePCK in biology at selected secondary schools in the Lusaka province of Zambia. Specifically, the study sought to answer the following research questions:

1. How do biology teachers perceive their ePCK in biology?
2. Is there a relationship between teachers' gender, academic qualifications, teaching experience, type of school, and their perceived ePCK?

Gess-Newsome (2015) asserted that teachers are significant filters and amplifiers of PCK. Therefore, collecting data about their perceived ePCK is critical in identifying aspects of PCK that may need to be enhanced. The current study contributes knowledge to the PCK community by describing teachers' perceived ePCK in biology and offers knowledge of the implications for teaching, teacher education, and research. The implications of the findings lie in highlighting the grey areas in biology teachers' ePCK which may need to be promoted.

3. Methodology

The methodology employed by the study is described in this section under the subsections research and sampling design, research instrument, procedures, and analysis.

3.1 Research and Sampling Design

The study adopted the quantitative survey design because it allows for the collection of data from a relatively large sample and enables the generalisation of the findings to the target population (Creswell, 2014). The multi-stage sampling design was used to purposively select 14 secondary schools representing three types of schools (boarding, day, and national science, technology, engineering, and mathematics [STEM] schools) from three districts of Lusaka province. The population comprised all the biology teachers at the selected secondary schools, while the sample consisted of 54 teachers who responded to the questionnaire. The teachers from the selected schools were selected using simple random sampling and out of the 70 teachers invited to participate in the survey, 54 (77%) returned the questionnaire. The respondents' characteristics are shown in .

Table 1.

Table 1: Respondent characteristics (N = 54)

Characteristic	Category	Frequency	Percentage
Gender	Female	29	53.7
	Male	25	46.3
Academic qualification	Master's degree	3	5.6
	Bachelor's degree	41	75.2
	Diploma	10	18.5
Years of teaching experience	0 – 5	18	33.3
	6 – 12	21	38.9
	≥ 13	15	27.8

3.2 Research Instrument

The study used the Secondary School Teachers' Perceived ePCK Questionnaire (SSTPePCK) (Appendix 1) to collect data on teachers' perceived ePCK in biology. Part I of the questionnaire requested respondents' demographic data, such as gender, years of teaching experience, highest academic qualification, and type of school. Part II of the questionnaire comprised 26 statements about respondents' enactment of PCK in six components, namely students' prior knowledge, what makes the subject easy or difficult to understand, curricular saliency, conceptual teaching strategies, representations, and assessment. The 26 items were developed from a literature search, with most items adapted from Uner and Akkus' (2019) Secondary School Students' Perceptions of Their Teachers' Pedagogical Content Knowledge (SPTPCK) Scale, which had a reliability index (*a* value) of .925. The response options to the five-point questionnaire items were 1 = *strongly disagree*, 2 = *disagree*, 3 = *undecided*, 4 = *agree*, and 5 = *strongly agree*. The questionnaire was sent to peers and experts for content and face validation. The validators included two biology education lecturers, two biology teachers, and one English language teacher. Validators' comments were used to rephrase some statements for clarity.

The questionnaire was pilot tested with 17 teachers and the Cronbach's alpha value of .896 indicated that the items were reliable (Taber, 2018).

3.3 Procedures

The first author sought permission from the Ministry of Education Headquarters, District Education Board secretaries, and head teachers of the participating schools to conduct the research. Teachers voluntarily responded to the questionnaire, which was distributed and collected in the first and second terms of the school calendar from February 2022 to June 2022. To avoid disturbing the teaching and learning process, prior arrangements were made with the school administration, and appropriate dates were agreed upon for the administration of the questionnaire. Data were collected using a self-administered Likert-type questionnaire for teachers. The respondents were required to select the most appropriate response, on a five-point scale, ranging from strongly agree to strongly disagree, to describe their ePCK in biology. The respondents completed the questionnaire at a time convenient to them, taking about 20 minutes.

3.4 Analysis

The analytical framework for the study comprised the following six PCK components: (a) assessment (ASS), (b) conceptual teaching strategies (CTS), (c) curricular saliency (CS), (d) what makes the subject easy or difficult to understand (WD), (e) students' prior knowledge and misconceptions (SPK), and (f) representations and analogies (RP). Similar to the analysis by Almutairi (2022), Busaka et al. (2022), and Lai and Lin (2018), the Likert-scale responses were treated as though they were continuous data, so that aggregated means and standard deviations were computed. Statistical Package for the Social Sciences (SPSS) version 20 was used to analyze the data. Descriptive statistics (means and standard deviations) were used to describe the respondents' perceived enactment of PCK, while inferential statistics (*t* test and analysis of variance [ANOVA]) were used to compare the respondents' perceived PCK enactment based on their characteristics (gender, academic qualification, teaching experience, and type of school).

4. Results

This section presents the results of the study concerning teachers' perceived PCK enactment in biology, and a comparison of teachers' perceived PCK enactment based on gender, academic qualification, teaching experience, and type of school. The respondents' responses were checked for normality and the results showed that the responses were approximately normally distributed ($W = 0.979$, $p = .450$). Therefore, appropriate parametric tests were performed on the data.

4.1 Teachers' Perceived PCK Enactment in Biology

The results showed that the respondents' perceived PCK enactment in biology was high, as shown in Table 2. The respondents rated themselves above 4 for overall PCK and 3.77 or above for the components of PCK. The respondents' least enacted PCK component was WD, while the most enacted component was SPK.

Table 2: Respondents' PCK enactment

Perceived enactment of PCK			
	M	SD	Level of perceptions
Overall PCK	4.29	.37	High
Perceived enactment of PCK components			
	M	SD	Level of perceptions
SPK	4.43	.47	High
WD	3.77	.62	Moderate
CS	4.36	.41	High
CTS	4.42	.45	High
RP	4.41	.53	High
ASS	4.35	.49	High

4.2 Teachers' Perceived PCK Enactment Based on Gender

Table 3 shows the independent *t* test results for the respondents' perceived ePCK by gender.

Table 3: Respondents' perceived PCK enactment by gender

Respondents (N = 54, female = 29, male = 25)						
Perceived enactment of PCK						
	Gender	M	SD	df	*t*	*p*
PCK	Female	4.36	.37	52	1.542	.129
	Male	4.21	.35			
Perceived enactment of PCK components						
	Gender	M	SD	df	*t*	*p*
SPK	Female	4.39	.49	52	-0.595	.554
	Male	4.47	.44			
WD	Female	3.89	.64	52	1.555	.126
	Male	3.63	.57			
CS	Female	4.48	.40	52	2.414	.019*
	Male	4.22	.38			
CTS	Female	4.41	.46	52	-0.051	.960
	Male	4.42	.43			
RP	Female	4.51	.49	52	1.489	.143
	Male	4.29	.56			
ASS	Female	4.47	.49	52	1.986	.052
	Male	4.21	.47			

*Significant at $p = .05$

Regarding the influence of gender on respondents' perceived PCK enactment, the independent samples *t* test results showed that there was no significant difference in the respondents' perceived ePCK ($t[52] = 1.54$, $p = .129$) based on gender. With regard to perceived enactment of the PCK components, the respondents' perceptions did not differ by gender, except for the component CS ($t[52] = 2.414$, $p = .019$).

4.3 Teachers' Perceived PCK Enactment Based on Academic Qualification

Table 4 shows respondents' perceived ePCK based on their highest academic qualifications.

Table 4: Respondents' perceived PCK enactment based on their academic qualification

Respondents (diploma = 10, bachelor's degree = 41, master's degree = 3)					
Perceived enactment of PCK					
	Highest qualification	M	SD	*F*	*p*
Overall PCK	Diploma	4.01	.31	3.989	.025*
	Bachelor's degree	4.35	.36		
	Master's degree	4.39	.29		
Perceived enactment of PCK components					
	Highest qualification	M	SD	*F*	*p*
SPK	Diploma	4.07	.49	4.143	.022*
	Bachelor's degree	4.51	.41		
	Master's degree	4.44	.69		
WD	Diploma	3.45	.49	1.710	.191
	Bachelor's degree	3.84	.63		
	Master's degree	3.92	.52		
CS	Diploma	4.06	.51	3.993	.024*
	Bachelor's degree	4.41	.36		
	Master's degree	4.62	.29		
CTS	Diploma	4.20	.55	1.602	.212
	Bachelor's degree	4.46	.41		
	Master's degree	4.58	.38		
RP	Diploma	4.10	.49	2.173	.124
	Bachelor's degree	4.48	.53		
	Master's degree	4.44	.19		
ASS	Diploma	4.18	.44	0.720	.492
	Bachelor's degree	4.39	.51		
	Master's degree	4.33	.42		

*Significant at $p = .05$

The majority of the respondents (41) were bachelor's degree holders, followed by diploma holders (10) and master's degree holders (3). The one-way ANOVA was conducted to compare the respondents' perceived PCK enactment based on their academic qualification. The results in Table 4 show that the perceived PCK enactment of diploma, bachelor's degree, and master's degree holders were significantly different ($F[2, 51] = 3.989$, $p = .025$). Tukey's Honest Significant Difference (HSD) post hoc test showed that there were statistically significant differences in the perceived PCK enactment of diploma and bachelor's degree holders ($p = .021$). However, there were no statistically significant differences between diploma and master's degree holders ($p = .225$) and master's degree and bachelor's degree holders ($p = .977$).

Furthermore, there was a statistically significant difference in respondents' perceived enactment of the components SPK ($F[2, 51] = 4.143$, $p = .022$) and CS

(F[2, 51] = 3.993, p = .024). However, there were no statistically significant differences in the perceived enactment of the components WD, CTS, RP, and ASS. The post hoc analysis using Tukey's HSD test revealed that the mean perceived ePCK of diploma holders was significantly lower for SPK (p = .016) and CS (p = .035). Results showed that respondents' perceptions for overall PCK and all components were highest for master's degree holders followed by bachelor's degree and diploma holders, respectively.

4.4 Teachers' Perceived PCK Enactment Based on Teaching Experience

The one-way ANOVA (Table 5) was performed to compare respondents' perceived PCK enactment based on their teaching experience.

Table 5: Respondents' perceived PCK enactment based on teaching experience

Respondents (0 – 5 years = 18, 6 – 12 years = 21, ≥ 13 = 15)					
Perceived enactment of PCK					
	Teaching exp. (years)	M	SD	*F*	P
Overall PCK	0 – 5	4.33	.36	0.304	.739
	6 – 12	4.24	.37		
	≥ 13	4.31	.38		
Perceived enactment of PCK components					
	Teaching exp. (years)	M	SD	*F*	*P*
SPK	0 – 5	4.10	.45	0.212	.810
	6 – 12	4.48	.36		
	≥ 13	4.38	.62		
WD	0 – 5	3.79	.63	0.210	.811
	6 – 12	3.72	.59		
	≥ 13	3.83	.67		
CS	0 – 5	4.34	.46	0.022	.978
	6 – 12	4.37	.39		
	≥ 13	4.37	.41		
CTS	0 – 5	4.54	.45	1.335	.272
	6 – 12	4.31	.43		
	≥ 13	4.42	.45		
RP	0 – 5	4.52	.43	0.695	.504
	6 – 12	4.32	.62		
	≥ 13	4.40	.51		
ASS	0 – 5	4.36	.53	0.617	.544
	6 – 12	4.27	.54		
	≥ 13	4.45	.38		

The one-way ANOVA revealed that there were no significant differences in the respondents' perceived enactment of PCK (F[2, 51] = 0.304, p = .739) and all PCK components based on teaching experience. The results showed that teaching experience did not influence respondents' perceived PCK enactment in biology and that the mean was the lowest for the component WD.

4.5 Teachers' Perceived PCK Enactment Based on Type of School

Results for respondents' perceived ePCK based on type of school are presented in Table 6.

Table 6: Respondents' perceived PCK enactment based on the type of school

Respondents (boarding = 13, day = 38, national STEM = 3), df = 2, 51					
Perceived enactment of PCK					
	Type of school	M	SD	*F*	*p*
PCK	Boarding	4.31	.42	0.082	.921
	Day	4.27	.35		
	National STEM	4.35	.43		
Perceived enactment of PCK components					
	Type of school	M	SD	*F*	*p*
SPK	Boarding	4.51	.38	0.476	.624
	Day	4.39	.49		
	National STEM	4.56	.51		
WD	Boarding	4.02	.73	1.893	.161
	Day	3.66	.58		
	National STEM	4.00	.25		
CS	Boarding	4.22	.51	1.206	.308
	Day	4.41	.38		
	National STEM	4.24	.41		
CTS	Boarding	4.44	.50	0.093	.911
	Day	4.40	.43		
	National STEM	4.50	.50		
RP	Boarding	4.44	.53	0.036	.965
	Day	4.39	.54		
	National STEM	4.44	.51		
ASS	Boarding	4.23	.59	0.490	.615
	Day	4.39	.46		
	National STEM	4.33	.58		

Regarding type of school, the respondents' perceived PCK enactment was high and the type of school (boarding, day, and national STEM schools) did not influence their perceived ePCK significantly. Respondents' perceived enactment of overall PCK was not influenced by the type of school they worked at (F[2, 51] = 0.082, p = .921). These results show clearly that the type of school did not influence the respondents' perceived PCK enactment in biology.

5. Discussion

In this section, the implications of the results for practice, policy, and research are discussed in light of the literature.

5.1 Teachers' Perceived PCK Enactment in Biology

Generally, the respondents' perceived ePCK in biology was high, implying that they perceived their ePCK to be developed. Based on Mazibe et al. (2018), who found that teachers' reported and enacted PCK were mostly equal, it may be assumed that if teachers' ePCK is as high as they perceive it, higher accomplishment may be attained by students. Since teachers with developed PCK are more likely to use instructional strategies which tend to promote meaningful learning among students, students' learning may be enhanced. However, teachers' views about their teaching may not be perceived in the same way by others, such as students (Budge & Cowlishaw, 2012). This suggests a need for future research to triangulate data sources on teachers' ePCK by observing the actual enactment of PCK during teaching. Research may also compare teachers' perceived enactment of PCK with students' perceptions of teachers' PCK.

5.2 Influence of Gender and Type of School on Teachers' Perceived PCK Enactment in Biology

The finding that gender did not influence respondents' perceived PCK enactment supports Park et al. (2020), who reported no significant difference in teachers' PCK scores based on gender. Furthermore, the findings are similar to Busaka et al. (2022), who found that there were no significant differences in the perceptions of male and female teachers. This result was expected, as the teachers are trained in the same courses and are expected to teach the same content regardless of their gender. Therefore, their perceived ePCK was expected to be the same.

According to the results, the type of school did not influence respondents' perceived ePCK in biology. It was discovered that respondents in boarding and national STEM schools enacted PCK the same way as those in day schools, even though they had more access to teaching-learning materials (e.g., libraries, laboratories, and textbooks), which may influence the way teachers enact their PCK. This may be explained by the fact that teachers offer the same syllabus at all types of schools and receive the same training in content at the college and university level.

5.3 Influence of Teachers' Academic Qualification and Teaching Experience on Perceived PCK Enactment in Biology

The respondents' perceived PCK enactment was influenced by their highest academic qualifications, with diploma holders having lower perceived ePCK than bachelor's degree and master's degree holders, respectively. This finding supports Park et al. (2020), who found that teaching certification and teaching at a high school influenced teachers' total PCK scores. This may influence teachers' motivation, creativity, and persistence during the preparation and implementation of lessons. As the respondents' perceived PCK enactment was high, this may positively affect how they employ their PCK during the teaching process in class (Hartadiyati & Sutikno, 2015). The results suggest that teachers' perceived PCK enactment increases with higher academic qualifications. This

finding was not expected for the secondary school level, as all teachers learn higher level content than they are expected to teach. The diploma holders' lower self-ratings could point to a need for them to have their PCK enhanced through teacher professional development.

The study also showed that teaching experience did not influence respondents' perceived PCK enactment. This finding supports other studies (Mapulanga et al., 2022; Park et al., 2020; Park & Chen, 2012; Suprayogi et al., 2017). The results also support Busaka et al. (2022), who found that the perceptions of teachers towards integrating soft skills in mathematics lessons were not influenced by the number of years they had taught. However, the results contradict the findings by Friedrichsen et al. (2009), who found that teachers' teaching experience had contributed to their knowledge of PCK components. The results also counter the assertion that PCK develops with teaching experience. The study found that the perceived PCK enactment of teachers with more than 13 years of teaching experience was not significantly different from that of those with 0 to 5 years of teaching experience. This finding counters the assertion by Liu et al. (2010) that experienced teachers have a broader knowledge of educational practices and as a result, have more favorable perceptions of their instructional approaches and practices. Since PCK has been observed to develop with practice and experience with the topics or subject matter, it was expected that teachers who had taught for many years would have higher perceived PCK enactment compared to their counterparts who had taught for only a few years. This suggests that the experienced teachers who participated in the current study have not reflected deeply on their teaching experiences.

5.4 Most Enacted PCK Component

The study found that the component SPK was the most enacted PCK component. This implies that respondents felt that they most frequently integrated students' prior knowledge in their teaching, suggesting that respondents had developed knowledge of SPK. This finding contradicts the findings by Mthetwa-Khunene et al. (2015), who concluded that the teachers in their study had inadequate knowledge of the component of students' prior knowledge of genetics. The significance of SPK for teaching and learning is that it empowers teachers to make effective pedagogical decisions concerning the concepts to be taught (Lee & Luft, 2008). It may mean that teachers know their students' prior knowledge so that they can prepare and conduct lessons that build on what the students already know about biology topics. This would also enable teachers to use appropriate instructional strategies to help students overcome their misconceptions and learning difficulties.

5.5 Least Enacted PCK Component

The finding that the component what makes the subject easy or difficult to understand (WD) was the least enacted component is a serious concern for the success of educational activities. This finding is consistent with a previous study on planned TSPCK which found that WD was the least integrated component (Mapulanga et al., 2022). This finding also supports Kaya et al. (2021), who concluded that pre-service teachers had low knowledge of students' learning difficulties. The finding implies that if teachers do not know the aspects of the

content that make it easy or difficult to learn the subject, it becomes almost impossible for them to plan and enact lessons that may result in meaningful learning. They may not know the aspects of the subject that require dedicated time to be taught and/or understood, and so may fail to guide the students appropriately. There is a serious need for teachers' knowledge of this component (WD) to be enhanced as it is needed to make students comprehend the topics that are perceived to be difficult.

6. Conclusion and Recommendations

This study examined secondary school teachers' perceived PCK enactment in biology. The findings indicated that respondents' perceived PCK enactment in biology was high, implying that respondents generally felt that they enact developed PCK in biology. The results also revealed that academic qualification was significantly related to the perceived enactment of PCK. However, the respondents' perceived enactment of PCK did not differ significantly based on gender, type of school, and teaching experience. The findings are relevant, as they point out some grey areas in teachers' knowledge that need to be given the necessary attention both at the teacher training and professional development level. Since the study revealed that respondents' PCK was influenced by their qualifications, there is a need to enhance teachers' PCK, especially for the component what makes the subject easy or difficult to understand, which was the least enacted. The study also recommends enhancing teachers' PCK in the components where respondents showed differences based on their demographic characteristics. Future research should use a larger sample and multiple data collection tools, such as interviews and document analysis of planning documents, to triangulate the findings.

7. Limitations

The study was limited in some methodological aspects, such as data collection methods and sample size, which may affect the generalization of the findings. Although the study only collected data using a Likert-type questionnaire, the findings remain valuable as the analysis employed involved the constant comparison with results from other contexts, namely sample, subjects, and regions. Despite the findings relating to the perceived PCK enactment of a smaller sample (54 teachers), which may not be representative of all biology teachers in Zambia, they provide an idea of the needed praxis interventions. Furthermore, the findings are relevant as they offer a glimpse of the possible prevailing teaching and learning situation at the three types of secondary schools represented in the study. The use of individuals from different types of public secondary schools in Zambia also added to the validity of the findings.

8. Acknowledgment

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Appendix 1: Secondary School Teachers' enacted PCK Questionnaire

Part I: Biographic Information

Please tick where applicable

1. What is your gender?
   Male [ ] Female [ ]
2. What is your highest academic/teaching qualification?
   Diploma [ ] Degree [ ] Master's [ ]
3. Indicate your years of teaching experience
   0 to 5 [ ] 6 to 12 [ ] 13 and more [ ]
4. State the type of your school
   Day school [ ] Boarding school [ ] National STEM school [ ]

Part II: Enactment of Pedagogical Content Knowledge

Please state (tick or cross) the extent to which you agree/disagree with each statement below.

SA= Strongly agree, **A** = Agree, **U** = Undecided, **D** = Disagree, **SD** = Strongly disagree

Statements	Responses				
	SA	**A**	**U**	**D**	**SD**
Students' prior knowledge					
1. The questions I ask when introducing the topic reveal how much my students know about the topic.					
2. The questions I ask in class evaluate how much my students have learned about the biology topic.					
3. The tests and exercises I give my students reveal how much they have learned in class.					
What makes the topic/subject easy or difficult					
4. I warn my students about the topics/concepts they may find difficult to learn.					
5. I explain the points commonly misunderstood by students by giving reasons.					
6. I immediately notice when my students have difficulty learning a topic/concept.					
7. I immediately notice why my students have difficulty learning a topic.					
Curricular saliency					
8. I inform my students about the biology syllabus.					
9. The questions I ask in class give clues about important points regarding the topic/concept.					
Conceptual teaching strategies					
10. I explain how and where my students can use the knowledge they learn.					
11. I explain how my students will use the knowledge they learn in further topics/concepts.					

Statements	Responses				
	SA	**A**	**U**	**D**	**SD**
12. I assist my students to establish the relationship between the biology topics they learn and previous topics.					
13. I assist my students to establish the relationship between the topics they learn and other subjects.					
14. I clearly explain biology concepts to my students.					
15. I perform activities specific to the topic, such as demonstration/experiment, simulation, animation, and display of teaching aids.					
16. I give situations about the topic/concept to explain concepts in class.					
17. I am aware of the skills required to use materials in an activity.					
18. I encourage learners to express their views in class.					
19. I give examples from daily life experiences to explain biology concepts.					
Representations					
20. I use teaching aids specific to the biology topic, such as figures, diagrams, simulations, models, and drawings.					
21. I use materials and activities to facilitate learning of the concepts in biology.					
Assessment					
22. I give class and homework exercises, assignments, and projects about biology topics.					
23. I use different types of questions, such as open-ended, multiple-choice, and filling in the blanks, in tests.					
24. For different topics, I use different types of questions, such as open-ended, multiple-choice, and filling in the blanks.					
25. During a term, I use different assessment methods, such as assignments, projects, classroom and homework exercises, tests, and experiments.					
26. The homework I give can be done using the knowledge my students learn in class.					

Thank you very much for completing this questionnaire!!