International Journal of Learning, Teaching and Educational Research
Vol. 22, No. 1, pp. 94-111, January 2023
https://doi.org/10.26803/ijlter.22.1.6
Received Sep 13, 2022; Revised Dec 19, 2022; Accepted Jan 17, 2023

Students' Perceptions of Biology Teachers' Enacted Pedagogical Content Knowledge at Selected Secondary Schools in Lusaka Province of Zambia

Thumah Mapulanga*
African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science, University of Rwanda, College of Education, Kayonza, Rwanda

Gilbert Nshogoza
Rwanda Institute for Conservation Agriculture, Department of Academics, Research and Extension, Bugesera, Rwanda

Ameyaw Yaw
University of Education, Department of Biology Education, Faculty of Science Education, Winneba, Ghana

Abstract. Since teachers' pedagogical content knowledge (PCK) plays a vital role in attaining educational goals, it has become a favourable construct in science education research. Because students are more perceptive when evaluating teachers, this quantitative survey examined students' perceptions of biology teachers' enacted PCK (ePCK). The sample consisted of 319 students from six secondary schools in three districts of Lusaka province, Zambia. Data were collected using a Likert-scale questionnaire called "students' perceptions of teachers' enacted PCK" questionnaire. It had a Cronbach's alpha value of 0.842, indicative of good reliability. Data were collected on six ePCK components: curricular saliency, what makes the subject easy or difficult to understand; conceptual teaching strategies; representations; students' prior knowledge; and assessment. The findings revealed that the students perceived that their biology teachers' ePCK was moderate (M=3.61, SD=0.47). While the component 'students' prior knowledge' was the most enacted (M=4.01, SD=0.73), while 'what makes the subject difficult to understand' was the least enacted component (M=3.01, SD=0.77). Statistically significant differences were observed in students' perceptions pertaining to the variables grade level and type of school but not gender. These findings suggest that students' perceptions of the teachers' ePCK may highlight areas that teachers may reflect on to

*Corresponding author: *Thumah Mapulanga, thumahm@gmail.com*

improve their PCK and, hence, students' learning. The implications of these findings on teaching and learning were discussed. The study recommends using students' perceptions to evaluate teachers' knowledge and the general teaching-learning process.

Keywords: enacted pedagogical content knowledge; biology; teachers; students; secondary school

1. Introduction

1.1 Background to the Study

The provision of quality education to citizens has been on the top of the agenda of many countries across the globe (Guerreiro, 2017). A primary concern relates to improving the quality of science education, as many students face learning difficulties in science (Lin et al., 2016). In Zambia, for example, secondary school students continue to perform poorly in science subjects, including biology (Examinations Council of Zambia, 2018). The students' average pass percentage in biology in the school certificate examinations has not been satisfactory (Examinations Council of Zambia, 2018). This performance negatively affects students' progression in careers that require a pass in grade 12 biology examinations.

Several factors account for the students' poor performance in biology examinations, such as how the subject is taught (Mapulanga et al., 2022a) and teachers' professional knowledge (Soysal, 2017). As students regularly interact with teachers, their perceptions of teachers' professional knowledge can be used as the means to measure and describe the teachers' professional knowledge. The students' perceptions may be used to inform actions for teacher professional development (Halim et al., 2014). Students' perceptions influence their academic performance and can help teachers reflect on and develop their professional knowledge (Luft et al., 2022). Therefore, researchers (Akinyemi & Mavhunga, 2022; Halim et al., 2014; Uner & Akkus, 2019) have used students as a lens to measure their teachers' professional knowledge. These researchers have stressed the value of students' views in evaluating the teaching-learning process. Students' perceptions may also help teachers enhance students' learning experiences (Stobaugh et al., 2020). As students' perceptions influence their learning behaviour, students' views of the teaching processes may be more important than external opinions (André et al., 2020).

Shulman (1986, 1987) asserted that pedagogical content knowledge (PCK) distinguishes teachers from other subject specialists. For example, PCK distinguishes biology teachers from biologists. PCK is the knowledge teachers draw upon to transform content knowledge into what students can easily understand (Shulman, 1986). Since teachers with developed PCK have higher chances of leading students to achieve learning outcomes, research has investigated how PCK is documented and portrayed (Loughran et al., 2004; Park and Oliver, 2008), and developed (Anwar, 2018).

1.2 Theoretical Framework

This study was based on the theory of pedagogical content knowledge (PCK) (Shulman, 1986). PCK is the teachers' professional knowledge domain through which content is transformed into what students can easily understand. In the revised consensus model of PCK, students are recognised as critical modifiers and amplifiers of PCK (Carlson et al., 2019). However, students' response to teaching-learning may be influenced by their perceptions of the process, including teachers' knowledge, which would also influence their motivation and performance in the subject.

The current study modified and applied Mavhunga and Rollnick's (2013) model of topic-specific PCK (TSPCK). Mavhunga and Rollnick's model was developed for describing TSPCK based on the transformation of content through five content-specific components. However, the current study added another component (assessment) so that six components were used to describe the ePCK for the subject biology (see Table 1). Enacted PCK was conceptualised as the knowledge that is demonstrated by teachers during instruction, as perceived by the students.

Two assumptions were made for adopting and modifying the TSPCK model: (1) that the topic-specific components would apply to a subject (domain), and (2) additional components could be included in the model. Therefore, the six components were applied to describe teachers' pedagogical content knowledge in biology after including knowledge of assessment as an additional component. The components are conceptualised in Table 1.

Table 1: Conceptualisation of the PCK components

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

1.3 Students' Perceptions of Teachers' Professional Knowledge

Students' perceptions of teaching and learning have been used to measure and describe teachers' knowledge, including PCK (Halim et al., 2014; Jang et al., 2009;

Uner & Akkus, 2019). Since students filter and amplify teachers' PCK, their perceptions of teachers' PCK are critical in detecting weak areas in teachers' PCK (Gess-Newsome, 2015). The information about these areas may be used to identify the components of PCK that may need to be developed. Therefore, students' perceptions may contribute to forming a theoretical viewpoint on the development of PCK, which is highly significant in education.

Researchers have outlined the importance of students' perceptions in science education. For example, Uner and Akkus (2019) asserted that students' perceptions of teachers' PCK can help examine the effectiveness of the teaching-learning process. Luft et al. (2022) added that students are one factor contributing to the development of PCK. Further, Tuan et al. (2000) opined that students can judge their teachers' knowledge and expect them to possess high subject matter expertise to employ effective teaching approaches.

While students' views might not match the truth as seen by professionals, they may provide insight into the spectrum of reality in the classroom and may indicate areas that require improvement (Jang, 2011). This implies that although students' perceptions may inform the teaching-learning process, care should be taken to interpret students' data. Alternatively, such data may be supported by evidence gathered through other approaches, such as analysis of instructional plans, interviews, observations, and teachers' questionnaires.

As already mentioned, some studies have used students' perceptions or views to explore teachers' professional knowledge or at least some aspects of it. For example, Halim et al. (2014) investigated science teachers' PCK using perceptions of students of differing academic abilities. They concluded that the students perceived that all the six PCK components (subject matter knowledge, assessment concept representation, teaching strategies, teaching context, and students) were significant. Amalu et al. (2020) examined the relationship between senior secondary students' perception of teachers' mastery of the subject, class management, and their academic performance. They concluded that a positive perception of teachers and the subject would motivate students and improve their performance.

Further, Sofianidis and Kallery (2021) examined science teachers' practice using classroom observation and students' views. They reported that teachers' strong points in teaching included using representations, subject matter knowledge, questioning, explaining learning objectives, and knowledge of students' difficulties. However, teachers' practice related to teaching approaches, students' alternative conceptions of teaching, and inquiry and experiment-based learning was weak.

Wisniewski et al. (2020) investigated German students' perceptions of instructional quality and found some variance among grade levels, school types, and subject groups. In another study, Wisniewski et al. (2021) compared the perceptions of teachers and students of teaching quality in German secondary schools. They found that the students' perceptions of instructional quality ranged

from favourable to less favourable. Recently, Akinyemi and Mavhunga (2022) investigated learner views of pre-service teachers' enacted topic-specific PCK. They found that learners viewed pre-service teachers' integrated use of the TSPCK component as essential to their conceptual understanding.

1.4 Statement of the Problem

Studies show that much research on students' perception of teachers' professional knowledge or effectiveness has been conducted on students at different levels. The studies focused on different aspects of the teachers' professional knowledge. However, there appears to be limited research on secondary school students' perceptions of their biology teachers' PCK based on the six components of assessment, curricular saliency, students' prior knowledge, what makes the subject easy or difficult to learn, representations and conceptual teaching strategies.

Although students could be used to measure and develop teachers' PCK (Luft et al., 2022), little research has employed quantitative approaches to measure PCK from students' perspectives (Halim et al., 2014; Uner & Akkus, 2019). Most PCK research has used teachers as a lens to investigate teachers' PCK (Barendsen & Henze, 2019; Mapulanga et al., 2022a; Park & Chen, 2012).

In Zambia, where this study was conducted, there is limited research on teachers' PCK. Specifically, research on secondary school students' perceptions of teachers' PCK is lacking. To close this gap, the current study explored secondary school students' perceptions of biology teachers' enactment of PCK at selected secondary schools in Lusaka district, Zambia.

1.5 Aim and Research Questions

This study investigated secondary school students' perceptions of their teachers' PCK enactment in biology. Teachers' enactment of PCK may be influenced by context (Carlson et al., 2019), including students' gender, grade level and the type of their school. Therefore, this study investigated whether the variables gender, type of school (day, boarding and technical schools), and grade level (grades 10, 11 and 12) influence students' perceptions of biology teachers' enactment of PCK.

The specific research questions were as follows:

1. What are the secondary school students' perceptions of their biology teachers' enacted pedagogical content knowledge?
2. Do secondary school students' perceptions of teachers' ePCK in biology differ based on gender, type of school and grade level?

1.6 Significance of the Study

This study examined secondary school students' perceptions of their teachers' ePCK in biology. The study's findings identified gaps in biology teachers' ePCK that need to be filled in. The findings also provided information to aid the measurement and growth of teachers' PCK through teacher professional development (Luft et al., 2022), as well as the possibility of utilising students' perceptions to assess the teaching-learning process. This information might help teachers and supervisors examine the effect of teachers' knowledge on students'

learning. When teachers become aware of students' perceptions of their PCK, they may begin to structure lessons that meet the students' expectations (Halim et al., 2014).

2. Methodology

This section presents the methodology and procedures employed to collect and analyse the data. It details the following subsections: research design, sampling, research instrument, procedures and ethical considerations, and data analysis.

2.1 Research Design

This study adopted a quantitative survey research design (Creswell, 2014). This design allows the collection of data from a large sample within a relatively short period of time.

2.2 Sampling

A total of six secondary schools were purposively selected based on proximity and type of school; the selected schools were either day, boarding or technical secondary schools. These schools were selected from Lusaka, Chongwe and Chilanga districts of Lusaka province. The sample comprised 319 students (122 females and 197 males) drawn using the simple random sampling technique. The students were selected from grades 10, 11 and 12, as shown in Table 2.

Table 2: Variables: Students' characteristics (n = 319)

Variables: Students' Characteristics	Category	Frequency	Percentage
Gender	Female	122	38.2
	Male	197	61.8
Grade	10	74	23.2
	11	125	39.2
	12	120	37.6
Type of school	Day	182	57.1
	Boarding	99	31.0
	Technical	38	11.9

2.3 Research Instrument

The study used a five-point survey questionnaire to collect data. According to Young (2016), survey questionnaires are preferred because they are relatively easy to use and allow the collection of data from larger samples. Therefore, a five-point Likert scale questionnaire (Appendix 1) was adapted from a validated scale with an alpha value of 0.925 (Uner & Akkus, 2019).

The adapted questionnaire consisted of 27 items, based on six components of pedagogical content knowledge, as shown:

a) Curricular saliency (CS) — eight items.
b) What makes a subject easy/difficult to understand (WD) — four items.
c) Conceptual teaching strategies (CTS) — five items.
d) Students' prior knowledge, including misconceptions (SPK) — three items.
e) Representations and analogies (RP) — two items.
f) Assessment (ASS) — five items.

The questionnaire was sent to two biology education experts, two biology teachers, and one English language teacher for content and face validation. Their recommendations on the clarity and completeness of the items were used to make them clear and concise. The questionnaire was also piloted with 24 secondary school students and a Cronbach's alpha value of 0.842 was obtained, indicative of internal consistency (Taber, 2018).

2.4 Procedure and ethical consideration

Permissions were obtained from the Ministry of Education Headquarters, District Education Board Secretaries, and headteachers of the selected schools before surveying the students. The students voluntarily participated in the study and were not required to indicate their names on the questionnaires. The survey questionnaires were administered to the selected students who were requested to describe their perceptions of teachers' ePCK in biology. The students were asked to select the most suitable response from strongly agree, agree, undecided, disagree, to strongly disagree. The first author was available to answer students' queries. For example, some students sought clarification on whether they only had to make one choice per item. Completing the questionnaires took approximately 25 minutes.

2.5 Data Analysis

The Statistical Package for the Social Sciences (SPSS) version 20 was used to analyse the data. The responses were treated as though they were continuous data, so that aggregated means and standard deviations were computed (Lai & Lin., 2018; Mapulanga et al., 2022b). Therefore, appropriate descriptive statistics (means and standard deviations) were used to describe students' perceptions of teachers' ePCK. Inferential statistics (t-tests and analysis of variance) were used to compare the students' perceptions of teachers' ePCK based on the variables of gender, grade level, and type of school.

3. Results

This section presents the findings of the study concerning students' perceptions of teachers' PCK for six PCK components, namely curricular saliency (CS); what makes a subject easy or difficult to understand (WD); conceptual teaching strategies (CTS); students' prior knowledge, including misconceptions (SPK); representations and analogies (RP); and assessment (ASS). The data were checked for normality using the Kolmogorov-Smirnov test, which revealed that the distribution of students' responses was approximately normal (p = .094) at the significance level of .05. Therefore, appropriate parametric tests were performed. A key for interpreting the means was developed as shown in Table 3. Firstly, the students' overall perceptions are presented, followed by the results based on the variables gender, grade level and type of school respectively.

Table 3: Key for interpreting the means

Mean range	Level of perceived ePCK
1.0 to 1.9	Very low
2.0 to 2.9	Low
3.0 to 3.4	Undecided
3.5 to 3.9	Moderate
4.0 to 4.5	High
4.6 to 5.0	Very high

3.1 Students' Perceptions of their Teachers' EPCK in Biology

The study revealed that the students perceived that their teachers' ePCK (ePCK) was generally moderate (*M* = 3.61, *SD* = .47) as shown in Table 4. With regards to perceptions for the PCK components, the results showed that students' perceptions were high for SPK. However, the students were undecided for WD, indicating that teachers' enactment of WD was low. The enactment of the other components was moderate.

Table 4: Students' perceptions of their teachers' ePCK in biology

Perceptions of ePCK				
	N	*M*	*SD*	Level
Overall PCK	319	3.61	.47	Moderate
Perceptions of ePCK components				
	N	M	SD	Level
SPK	319	4.01	.73	High
WD	319	3.01	.77	Undecided
CS	319	3.73	.61	Moderate
CTS	319	3.63	.68	Moderate
RP	319	3.78	.92	Moderate
ASS	319	3.48	.87	Moderate

3.2 Students' Perceptions of Teachers' EPCK Components by Gender

The results of the independent samples t-test in

Table 5 show that students' perceptions of teachers' ePCK for males (*M* = 3.62, *SD* = .44) and females (*M* = 3.60, *SD* = .44) were not statistically significantly different [*t* (317) = -.437, *p* = .662] at the significance level of .05. Concerning ePCK components,

Table 5 shows that students' perceptions did not differ by gender for all the ePCK components.

Table 5: Students' perceptions of ePCK components by gender

Students (n=319, females=197, males=122)

Perceptions of ePCK						
	Gender	*M*	*SD*	df	*t*	*p*
	Female	3.59	.48	-.437	317	.662
	Male	3.62	.44			
Perceptions of ePCK components						
	Gender	*M*	*SD*	df	*t*	*p*
SPK	Female	4.07	.79	301.21	1.792	.074
	Male	3.92	.62			
WD	Female	2.95	.78	317	-1.684	.094
	Male	3.10	.78			
CS	Female	3.77	.61	317	1.292	.197
	Male	3.68	.60			
CTS	Female	3.59	.69	315	-1.390	.166
	Male	3.70	.67			
RP	Female	3.81	.92	313	.679	.498
	Male	3.74	.92			

ASS	Female	3.40	.91	282.92	1.937	.054
	Male	3.59	.79			

3.3 Students' Perceptions of Teachers' EPCK Based on their Grade Level

Table 6 shows that the students' perceptions of teachers' ePCK based on their grade level (grade 10, 11 and 12) were significantly different [F (2,52 = 10.640, p < .001]. Also, their perceptions of ePCK components were significantly different for the components: WD [F (2,316) = 4.04, p = .019]; RP [F (2,316) = 14.18, p <.01]; ASS [F (2,316) = 3.48, p = .032]; and SPK F (2,316) = 7.47, p = .001].

Furthermore, the post hoc analysis using Tukey's Honest Significant Difference (HSD) criterion revealed that there were statistically significant differences between the perceptions of students in grades 10 and 12 for WD (p = .014) grades 10 and 11 for RP (p = .001), ASS (p = .032) and SPK (p = .001), and between grades 11 and 12 for SPK (p = .022). The students' perceptions for the components CS and CTS were not significantly different.

Table 6: Students' perceptions of teachers' ePCK based on grade level

(G10 = 74, G11 = 125, G12 = 120)

Perceptions of ePCK					
	Grade	*M*	*SD*	*F*	*p*
Overall PCK	10	3.75	.41	10.640	<.001*
	11	3.47	.49		
	12	3.67	.45		
Perceptions of ePCK component					
	Grade	*M*	*SD*	*F*	*p*
SPK	10	4.22	.59	7.465	.001*
	11	3.83	.79		
	12	4.08	.71		
WD	10	3.22	.711	4.038	.019*
	11	2.99	.81		
	12	2.90	.75		
CS	10	3.77	.55	2.274	.105*
	11	3.64	.65		
	12	3.80	.58		
CTS	10	3.72	.73	1.642	.195
	11	3.55	.66		
	12	3.66	.67		
RP	10	3.65	.81	3.475	.032*
	11	3.33	.84		
	12	3.52	.92		
ASS	10	3.65	.81	3.475	.032*
	11	3.33	.84		
	12	3.52	.92		

* Significant at p = .05

3.4 Students' Perceptions of Teachers' EPCK Based on the Type of their School

The results in Table 7 show statistically significant differences in students' perceptions of teachers' ePCK based on their type of school [F (2,316) = 7.367, p = .001]. Further analysis using Tukey's HSD criterion revealed that the perceptions (means) of students from boarding and day schools (p = .026), boarding schools,

and the technical school (p = .001) were significantly different. Further, statistically significant differences were observed in their perceptions for the components SPK, CTS, RP, and ASS. Except for the component WD (M = 2.89, SD = .86), the means for the technical school were higher for all PCK components. The analysis, using Tukey's HSD criterion, revealed that the perceptions (means) of students from boarding and technical schools for CTS (p = .001); technical and day schools for CTS (p = .036); boarding and technical schools for RP (p = .016); technical and boarding schools (p < .001) and technical and day schools (p = .001) for ASS; boarding and day schools (p < .001) and boarding and technical schools (p = .049) for SPK were statistically and significantly different.

Table 7: Students' perceptions of teachers' ePCK components based on the type of school

Students (Boarding = 99, Day = 182, Technical = 38), df = 2,316					
Perceptions of ePCK					
	Type of school	*M*	*SD*	*F*	*p*
Overall PCK	Boarding	3.48	.49	7.367	.001*
	Day	3.63	.45		
	Technical	3.80	.43		
Perceptions of ePCK components					
	Type of school	*M*	*SD*	*F*	*p*
SPK	Boarding	3.70	.86	14.847	<.001*
	Day	4.18	.65		
	Technical	4.02	.46		
WD	Boarding	3.05	.75	.530	.589
	Day	3.01	.77		
	Technical	2.89	.86		
CS	Boarding	3.75	.58	2.034	.133
	Day	3.69	.62		
	Technical	3.90	.58		
CTS	Boarding	3.48	.69	6.858	.001*
	Day	3.65	.66		
	Technical	3.95	.68		
RP	Boarding	3.59	.86	4.265	.015*
	Day	3.82	.95		
	Technical	4.08	.82		
ASS	Boarding	3.33	.87	14.847	<.001*
	Day	3.45	.89		
	Technical	3.98	.58		

* Significant at p = .05

4. Discussion of Results

This section presents the discussion of the results of the study, including the implications for practice. Further, the limitations of the study are discussed.

4.1 Students' Perceptions of Teachers' ePCK

The results show that the students' perceptions of their teachers' ePCK is moderate. These perceptions influence students' motivation since positive perceptions motivate students positively (Amalu et al., 2020). Students also perceive that their teachers enact all the five components of PCK but to various levels. The teachers' enactment of the PCK components has implications for

teaching and learning as it enables them to convey content in a way that students can understand (Akinyemi & Mavhunga, 2022). Therefore, the quality of PCK that teachers have reflects the quality of their teaching and, hence, students' learning. Since the study finds that students' perceptions are moderate, their teachers may have moderate PCK. It can be inferred that the quality of learning these students receive is moderate. However, these results contradict with teachers' perceptions of their ePCK. For example, a previous study found that teachers had high perceptions of their PCK enactment (Mapulanga et al., 2022b). The difference in students' and teachers' perceptions needs to be investigated further. A possible explanation is that teachers overrate themselves in self-reported PCK or that students underrate their teachers' ePCK.

Although the students in this study perceive that their teachers enacted the PCK components moderately, previous studies on teachers' actual PCK enactment revealed varying results. For example, Chapoo et al. (2014) found that their case teacher confidently implemented all five PCK components (knowledge of students' understanding of science, orientations toward science teaching, curriculum, assessment, and instructional strategies). Also, the finding that teachers' enacted knowledge of conceptual teaching strategies to a moderate level contradicts Sofianidis and Kallery (2021), who reported that teachers' knowledge of teaching approaches was weak.

The current study shows that students perceive that teachers' enacted knowledge of representations to a moderate extent. The results support Halim et al. (2014), who reported that low-achieving students did not consider teachers' knowledge of conceptual representation as significant for effective instruction. However, Sofianidis and Kallery (2021) found that knowledge of representations was among the teachers' strong points. Therefore, teachers need adequate knowledge of representation to present content in a clear and understandable way.

The result that 'what makes the subject easy or difficult to understand (WD)' is perceived to be the least enacted component raises fundamental questions about how effective instructional activities can be carried out. This outcome is also similar to findings from previous research; for instance, Mapulanga et al. (2022a) found that WD was the least integrated component in teachers' planned topic-specific PCK in respiration. This result corroborates the claim made by Uner and Akkus (2019) that student surveys were in line with those obtained by utilising other techniques. The results, however, counter Sofianidis and Kallery (2021), who concluded that teachers' expertise in understanding students' challenges is one of their strongest points.

It may be nearly impossible for teachers to prepare and deliver lessons that might lead to meaningful learning if they are unaware of the characteristics of the subject matter that make studying it easier or more challenging. Knowledge of students' difficulties may enable teachers to identify topics that require more time and effort to be taught and understood. and so may fail to guide the students appropriately. There is a severe and urgent need for the teachers' knowledge of this component (WD) to be enhanced.

The finding that students' perceptions are highest for the component 'students' prior knowledge including misconceptions (SPK)' implies that it was the most enacted component. However, the finding contradicts Sofianidis and Kallery's (2021) conclusion that the teachers in their study had weak knowledge of students' alternative conceptions. The findings also contradict Barendsen and Henze's (2019) observation that the teachers did not elaborate on students' misconceptions during instruction (actual PCK enactment).

Teachers having high knowledge of students' prior knowledge may enable them to choose effective teaching strategies as they would reflect on students' knowledge (Lee & Luft, 2008). This knowledge may enable them to conduct learner-centred lessons likely to enhance students' learning (Soysal, 2017). By reflecting on the knowledge of students, teachers can mould their PCK to enhance student learning. Therefore, teachers need to have advanced levels of knowledge of their students.

4.2 Students' Perceptions of Teachers' ePCK Based on Gender, Type of School, and Grade Level

The study finds that there are no differences in students' perceptions of teachers' ePCK based on their gender. This result was expected as the students are taught the same content, usually in the same classes, and are expected to meet the same criteria for the learning outcomes, regardless of their gender. However, this result contradicts the findings by Korte et al. (2013) and Stobaugh et al. (2020), who reported some differences in the students' perception of teaching effectiveness.

It was interesting that the students' perceptions are influenced by the type of their school. This may imply that the teachers at these schools enact their PCK differently, as these schools have some critical differences in access to teaching and learning facilities, such as laboratories and libraries. This may also be a result of other factors, such as teachers' characteristics that may influence students' perceptions of their teachers' knowledge which have not investigated in this study (Korte et al., 2013).

The study finds that there are differences in students' perceptions of teachers' PCK based on their grade level. This result is in line with the findings by Stobaugh et al. (2020). A possible explanation for the higher perceptions by the grade 10s is that they may not know what to expect from their teachers as they may still be young and cannot discern and understand the knowledge teachers ought to demonstrate in class. However, this may also imply that teachers have developed PCK for the biology topics taught in grade 10. The lower ratings by grade 11 and grade 12 students may imply that some teachers are unable to effectively teach some of the topics taught in the biology curriculum. Further, research has shown that teacher characteristics, such as gender and attitude towards students, can account for the observed differences in students' perceptions (Korte et al., 2013), although they have not been investigated in the current study.

5. Limitations of the study

A significant limitation of this study is the use of a Likert-scale questionnaire as the only source of collection but the results are still valuable since they give a sense of the prevailing teaching and learning situation at the selected schools. This is because the data represent the perceptions of many students as compared to the data that could be provided by one or two observers (Geiger & Amrein-Beardsley, 2019). Also, students' views are based on many lessons, unlike expert or researcher views that may be based on a few hours' lessons (van der Scheer et al., 2019). The validity of the results is further strengthened by involving students from different types of public secondary schools in the study. However, future investigations may utilise larger samples drawn from many districts across the country, and include interviews and observing lessons for triangulation purposes.

6. Conclusion and Recommendations

This study investigated students' perceptions of secondary school biology teachers' ePCK. The results showed that the students perceived that their biology teachers' ePCK was moderate, apart from knowledge of students' prior knowledge, which was perceived to be high. The results also showed that there were no statistically significant differences in students' perceptions of teachers' ePCK attributed to the students' gender. However, statistically significant differences were observed in students' perceptions of teachers' ePCK attributed to their grade level and type of school. The implication is that teachers may not differentiate their instruction based on their students' gender, but, given the context-specific nature of PCK, the teachers at the three types of schools may enact their pedagogical content knowledge differently.

The study recommends using students' perceptions to evaluate teachers' professional knowledge and the effectiveness of teaching and learning. The study also recommends improving teachers' ePCK in all the six PCK components. Future research may compare students' perceptions and their academic performance in biology. Research may also compare students' and teachers' perceptions of ePCK in biology.

Acknowledgment

The authors thank Prof. Lydia Mavuru and Prof. Overson Shumba for commenting on the academic rigour of the study. Also, thanks go to Mr Chileshe Busaka, Mr David Opanga and all colleagues who contributed during the various stages of the study.

Funding

This study was funded by the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS).

7. References

Akinyemi, O. S., & Mavhunga, E. (2022). The place of learner views in examining pre-service teachers' enacted topic-specific pedagogical content knowledge. *Proceedings of the 30th annual conference of the southern African association for research*

in mathematics, science, and technology education, Cape Town. https://www.sants.co.za/sants-30th-annual-saarmste-conference/

Amalu, M. N., Ngwu, M. E., Arop, L. O., & Obot, I. M. (2020). Students' perception of teachers' subject mastery, classroom management and students' academic performance in chemistry in Calabar Municipality, Cross River State, Nigeria. *European Journal of Scientific Research*, *156*(3), 253–261. http://www.europeanjournalofscientificresearch.com

André, S., Maulana, R., Helms-Lorenz, M., Telli, S., Chun, S., Fernández-García, C.-M., de Jager, T., Irnidayanti, Y., Inda-Caro, M., Lee, O., Safrina, R., Coetzee, T., & Jeon, M. (2020). Student perceptions in measuring teaching behavior across six countries: A multi-group confirmatory factor analysis approach to measurement invariance. *Front. Psychol*. *11*(273). https://doi.org/10.3389/fpsyg.2020.00273

Anwar, Y. (2018). Enhancing the prospective biology teachers' pedagogical content knowledge (PCK) through a peer coaching-based model. *Journal of Physics: Conference Series*, *1022*(1), 012059. https://doi.org/10.1088/17426596/1022/1/012059

Barendsen, E., & Henze, I. (2019). Relating teacher PCK and teacher practice using classroom observation. *Research in Science Education*, *49*(5), 1141–1175. https://doi.org/10.1007/s11165-017-9637-z

Carlson, J., Daehler, K. R., Alonzo, A., Barendsen, E., Berry, A., Boroswki, A., … Wilson, C. (2019). The refined consensus model of pedagogical content knowledge in science education. In A. Hume, R. Cooper, & A. Boroswki (Eds.), *Repositioning Pedagogical Content Knowledge in teachers' knowledge for teaching science* (pp. 77–92). Springer.

Chapoo, S., Thathong, K., & Halim, L. (2014). Biology teacher's pedagogical content knowledge in Thailand: Understanding & practice. *Procedia - Social and Behavioral Sciences*, *116*, 442–447. https://doi.org/10.1016/j.sbspro.2014.01.237

Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE.

Examinations Council of Zambia. (2018). *Examinations performance review*. Examinations Council of Zambia.

Geiger, T., & Amrein-Beardsley, A. (2019). Student perception surveys for K-12 teacher evaluation in the United States: A survey of surveys. *Cogent Education*, *6*(1). https://doi.org/10.1080/2331186X.2019.1602943

Gess-Newsome, J. 2015. A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK summit. In A. Berry, P. Friedrichsen, and J. Loughran (Eds.), *Re-examining pedagogical content knowledge in science education* (pp. 28–42). Routledge.

Guerreiro, S. (2017). *Pedagogical knowledge and the changing nature of the teaching profession*. Centre for Educational Research and Innovation, OECD. http://dx.doi.org/10.1787/9789264270695-en

Halim, L., Abdullah, S. I. S. S., & Meerah, T. S. M. (2014). Students' perceptions of their science teachers' pedagogical content knowledge. *Journal of Science Education and Technology*, *23*(2), 227–237. https://doi.org/10.1007/s10956-013-9484-2

Jang, S. J. (2011). Assessing college students' perceptions of a case teacher's pedagogical content knowledge using a newly developed instrument. *Higher Education*, *61*(6), 663–678. https://doi.org/10.1007/s10734-010-9355-1

Jang, S. J., Guan, S. Y., & Hsieh, H. F. (2009). Developing an instrument for assessing college students' perceptions of teachers' pedagogical content knowledge.

Procedia – Social and Behavioral Sciences, *1*(1), 596–606. https://doi.org/10.1016/j.sbspro.2009.01.107

Korte, L., Lavin., A. & Davies., T. (2013). Does gender impact students' perceptions of teaching effectiveness? *Journal of College Teaching & Learning (TLC)*, *10*(3), 167–178. https://doi.org/10.19030/tlc.v10i3.7933

Lee, E., & Luft, J. A. (2008). Experienced secondary science teachers' representation of pedagogical content knowledge. *International Journal of Science Education*, *30*(10), 1343–1363. https://doi.org/10.1080/09500690802187058

Lin, J., Yen, M.-H., Liang, J.-C., Chiu, M.-H., & Guo, C.-J. (2016). Examining the factors that influence students' science learning processes and their learning outcomes: 30 years of conceptual change research. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(9), 2617–2646. https://doi.org/10.12973/eurasia.2016.000600a

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, *41*(4), 370–391. https://doi.org/10.1002/tea.20007

Luft, J. A., Navy, S. L., Wong, S. S., & Hill, K. M. (2022). The first 5 years of teaching science: The beliefs, knowledge, practices, and opportunities to learn of secondary science teachers. *Journal of Research in Science Teaching*, 1–34. https://doi.org/10.1002/tea.21771

Mapulanga, T., Nshogoza, G., & Ameyaw, Y. (2022a). Zambian secondary school biology teachers' profiles of planned topic-specific pedagogical content knowledge for teaching respiration. *African Journal of Research in Mathematics, Science and Technology Education*, *26*(1), 1–16. https://doi.org/10.1080/18117295.2022.2085402

Mapulanga, T., Nshogoza, G., & Ameyaw, Y. (2022b). Teachers' perceived enacted pedagogical content knowledge in biology at selected secondary schools in Lusaka. *International Journal of Learning, Teaching and Educational Research*, *21*(10), 418-435. https://doi.org/10.26803/ijlter.21.10.23

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical equilibrium in pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education*, *17*(1–2). https://doi.org/10.1080/10288457.2013.828406

Park, S., & Chen, Y. C. (2012). Mapping out the integration of the components of pedagogical content knowledge (PCK): Examples from high school biology classrooms. *Journal of Research in Science Teaching*, *49*(7), 922–941. https://doi.org/10.1002/tea.21022

Park, S., & Oliver, J.S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, *38*(3), 261–284. https://doi.org/10.1007/s11165-007-9049-6

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–22. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Sofianidis, A., & Kallery, M. (2021). An insight into teachers' classroom practices: The case of secondary education science teachers. *Education Sciences*, 1–18. https://doi.org/10.3390/educsci11100583

Soysal, Y. (2017). An exploration of the interactions among the components of an experienced elementary science teacher's pedagogical content knowledge. *Educational Studies*, *44*(1), 1–25. https://doi.org/10.1080/03055698.2017.1331839

Stobaugh R., Mittelberg, J. & Huang, X. (2020. Examining K-12 students' perceptions of student teacher effectiveness. *Teacher Development*. 274-292. https://doi.org/10.1080/13664530.2020.1739740

Taber, K. S. (2018). The use of Cronbach's Alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Ting-ling Lai & Hsiao-Fang Lin (2018). An investigation of the relationship of beliefs, values, and technological pedagogical content knowledge among teachers, *Technology, Pedagogy and Education*, 1-14. https://doi.org/10.1080/1475939X.2018.1496137

Tuan, H. L., Chang, H. P., & Wang, K. H. W. (2000). The development of an Instrument for assessing students' perceptions of teachers' knowledge. *International Journal of Science Education*, *22*(4), 385–398. https://doi.org/10.1080/095006900289804

Uner, S., & Akkus, H. (2019). Secondary students' perceptions of their teachers' pedagogical content knowledge: a scale development study. *Teacher Development*, *23*(5), 566–587. https://doi.org/10.1080/13664530.2019.1674685

van der Scheer, E. A., Bijlsma, H. J., & Glas, C. A. (2019). Validity and reliability of student perceptions of teaching quality in primary education. *School Effectiveness and School Improvement*, *30*(1), 30–50. https://doi.org/10.1080/09243453.2018.1539015

Wisniewski, B., Röhl, S., & Fauth, B. (2021). The perception problem: a comparison of teachers' self-perceptions and students' perceptions of instructional quality. *Learning Environments Research*, *0123456789*. https://doi.org/10.1007/s10984-021-09397-4

Wisniewski, B., Zierer, K., Dresel, M., & Daumiller, M. (2020). Obtaining secondary students' perceptions of instructional quality: Two-level structure and measurement invariance. *Learning and Instruction*, *66*, 1–12. https://doi.org/10.1016/j.learninstruc.2020.101303

Young T.J. (2016). Questionnaires and surveys. In Zhu Hua (Ed.), *Research methods in intercultural communication: A practical guide (*pp. 165-180). Wiley.

Appendix 1. Questionnaire: Perception of Teachers' EPCK in Biology

Part I: Biographic Information

Please tick where applicable

1. What is your gender?
   Male [ ] Female [ ]
2. What is your grade level?
   Grade 10 [ ] Grade 11 [ ] Grade 12 [ ]
3. 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**	**DA**	**SDA**
Students' prior knowledge					
1. The questions my teacher asks about what he/she has taught evaluate how much I have learned.					
2. The questions my teacher asks before introducing any topic reveal how much I know about the topic.					
3. My teacher's examinations reveal how much I have learned in class.					
What makes the topic difficult to understand					
4. My teacher warns about the topics/concepts that I may find difficult.					
5. My teacher explains the points commonly misunderstood by students by giving reasons and examples					
6. My teacher immediately notices when I have difficulty learning a topic/concept.					
7. My teacher immediately notices why I have difficulty learning a topic.					
Curricular saliency					
8. My teacher informs us about the biology syllabus.					
9. The questions my teacher asks in class give clues about important points regarding the topic/concept.					
10. My teacher explains how and where I can use the knowledge I learn in class.					
11. My teacher explains how I will use the knowledge I learn in other topics/concepts.					
12. My teacher helps me to establish the relationship between the biology topic I learn and previous topics.					
13. My teacher helps me to establish the relationship between the topic I learn and topics in other subjects.					
14. My teacher clearly explains biology concepts					

15. My teacher asks us to clearly explain biology concepts					
Conceptual teaching strategies					
16. My teacher allows us to perform activities specific to the topic such as demonstration/experiment, simulation, animation, and teaching aids.					
17. My teacher uses stories about the topic/concept to explain concepts in class.					
18. Each time my teacher gives a task, he/she expects us to develop skills related to the topic					
19. My teacher encourages me to express my views in class.					
20. My teacher asks us to give examples from daily life to explain biology concepts.					
Representations, analogies, and examples					
21. My teacher uses teaching aids specific to biology topics, such as figures, diagrams, simulations, models, and drawings.					
22. My teacher uses materials and activities to facilitate my learning of the concepts in biology.					
Assessment					
23. My teacher gives the end-of-topic tests about the topic.					
24. My teacher gives class and homework exercises, assignments, and projects, and about biology topics.					
25. My teacher uses different types of questions such as open-ended, multiple-choice, and filling in the blanks in tests.					
26. During a term, my teacher uses different assessment methods such as assignments, projects, homework, experiments, and portfolio.					
27. The homework exercises my teacher gives can be done using the knowledge I learn in class.					

Thank you for completing this questionnaire