

Mathematics and Science Student Teachers' Self-Reported Pedagogies: A Case of Copperbelt University

Asiana Banda* Leonard Nkhata David Chituta Beauty Choobe Jack Jumbe
Copperbelt University, School of Mathematics and Natural Sciences, P.O. Box 21692, Kitwe, Zambia

Abstract
This descriptive survey study was aimed at exploring mathematics and science student teachers' pedagogical content knowledge (PCK) during teaching practice. The PCK surveyed focused on the pedagogies the student teachers used during their teaching practice. The sample comprised 106 mathematics and science student teachers from Copperbelt University in Zambia. This sample included mathematics, biology, physics, and chemistry education student teachers. Data were collected using a questionnaire designed by the authors. The results show that the most common pedagogies student teachers used were group discussion, lecture, demonstration, Question and Answer, and Problem Based Learning. The reasons they gave for using such pedagogies were that the pedagogies encourage interaction among learners, promote retention of knowledge, lack of adequate resources, and over enrolment. However, when using these pedagogies, they faced challenges such as class management due to over enrolment, inadequate teaching and learning resources, and inadequate time. These challenges prevented the student teachers from using their preferred pedagogies such as field trip, computer simulations, experiments, and inquiry. These results have implications to teacher education and pupils' understanding of concepts.
Keywords: pedagogy, pedagogical content knowledge, teaching practice, student teachers

1. Introduction

Pedagogical Content Knowledge (PCK) is an idea that was conceptualized in teacher education by Shulman (1986). Shulman introduced PCK as a possible answer to the so called "missing paradigm" in research and practice on teaching (Evens, Elen, & Depaepe, 2015). Before PCK was introduced, teaching was approached by only focusing on content or by exclusively focusing on pedagogy. Shulman believed that neither approach grasped every aspect of teachers' knowledge base (Evens, Elen, & Depaepe, 2015). Other educators developed on Shulman's idea and interpreted PCK differently. However, PCK still remains a new construct in teacher education that bridges the gap between subject matter content and pedagogy. According to Shulman, PCK is defined as ". . . that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding." (1987: 8). More specifically, he looked at PCK as "the ways of representing and formulating the subject that makes it comprehensible for others'' (Shulman, 1987:8). It may include the most powerful analogies, illustrations, examples, explanations, and demonstrations used by teachers to help their learners understand the concepts being taught.

As mentioned, other researchers developed on Shulman's idea of PCK. For example, Gess-Newsome and Lederman (1999) created a new model of PCK, based on Shulman's model, where PCK is seen as an overlap of the subject matter knowledge, contextual knowledge, and general pedagogical knowledge. Gess-Newsome and Lederman (1999) described PCK as that which is necessary for classroom teaching.

There are a number of ways in which PCK is developed in a teacher. First, PCK is developed through experience in teaching (Grossman, 1990; Kind, 2009; van Driel & Verloop, 1998). Significant improvements in PCK are made in the first few months of one's teaching career (Simmons, Emory, & Carter, 1999). This is the period when teachers are gaining experience and still developing their PCK. Second, PCK is developed by involvement in PCK courses aimed at improving teachers' knowledge on how to teach a particular subject (Grossman, 1990; Haston & Leon-Guerrero, 2008). The courses can either be through Continuous Professional Development (CPD) or through methodology courses during teacher training. Third, PCK is developed when the teacher has adequate subject matter knowledge – content knowledge (Grossman, 1990; Kind, 2009). Expertise in teaching cannot be developed without good subject matter knowledge. Fourth, PCK is developed by apprenticeship of observation (Grossman, 1990). This involves teachers' past experiences as a student. In most cases, teachers want to teach the way they were taught. Fifth, PCK is developed by interaction with colleagues (Kind, 2009). This interaction may be formal or informal.

PCK has been seen as an effective tool in communicating the subject matter knowledge to students. For example, Boz & Boz (2005), De Jong & Van Driel (2004), De Jong, Van Driel, & Verloop (2005), Van Driel, De Jong, & Verloop (2002) explored PCK for high school pre-service teachers. In general, these studies show that pre-service teachers have low PCK in chemistry. In particular, Boz and Boz (2005) examined Turkish pre-service teachers on the nature of PCK and its sources in the context of ordering topics. The pre-service teachers were asked to mention the order in which they would teach the topics; particulate nature of matter, condensation, and mass and volume. This was followed by an interview to gain more information about why the pre-service teachers chose a particular order. The interview revealed various factors that led to the pre-service teachers' PCK such as subject matter knowledge, and general pedagogical knowledge. According to Shulman (1987: 8), general pedagogical knowledge involves "broad principles and strategies of classroom management and organisation that appear to transcend subject matter", as well as knowledge about learners and learning, assessment, and educational contexts and purposes.

Furthermore, some studies show a development of teachers' PCK where there is an intervention. For example, Van Driel, De Jong, and Verloop (2002) investigated the development of PCK among chemistry pre-service teachers who were involved in a teacher education workshop. The PCK focused on how the pre-service teachers can relate the macroscopic to microscopic particles. More specifically, it focused on the relationship between observable phenomena like chemical reactions, and microscopic properties on the one hand and their interpretation in terms of corpuscular characteristics on the other hand. The pre-service teachers surveyed showed a great development of PCK on relating the macroscopic and microscopic levels to each other. This growth in PCK was attributed to teaching experience. Similarly, Van Driel and Verloop (1998) observed that familiarity and experience are essential for the development of PCK. As such, it can be deduced that PCK develops with increase in teachers' experience and exposure to teacher education program or PCK courses. This implies that teachers with less experience like the pre-service teachers have less developed PCK. However, due to poor staffing levels in Zambian secondary schools, new graduates are expected to deliver the content and help pupils pass national examinations and exhibit scientific literacy. Thus, such teachers are assigned to teach examination classes even before they have fully developed their PCK.

Similarly, at Copperbelt University (CBU), pre-service teachers go on teaching practice in third year. By the time pre-service teachers go on teaching practice, they have learnt enough content to help them develop their PCK. Teaching practice provides pre-service teachers with an opportunity to link authentic teaching experiences to educational literature on student conception. Student teachers at the CBU learn many pedagogies theoretically during training. Through teaching practice, they find opportunities to practice these pedagogies. The pedagogies used by the pre-service teachers often depend on the school environment and the choice of the student for convenience. The impact on learners achieving quality learning is affected by the pedagogies used by their teachers. Active learning in students require hands on learning which sometimes is limited due to lack of knowledge on how pedagogies are used or not having resources to implement certain pedagogies. Studies in Zambia that have explored pre-service science teachers' PCK during teaching practice are scarce. Yet Zambian pre-service teachers are expected to exhibit well developed PCK when they start teaching. As argued by Rosenkränzer, Hörsch, Schuler and Riess (2017), PCK can be promoted in teacher education. As such, this study was conducted to explore mathematics and science student teachers, who were on teaching practice, on their PCK. The PCK surveyed focused on pedagogies that the student teachers used during their teaching practice. The study was guided by the following research questions:

1. What pedagogies do student teachers often use during teaching practice?
2. What reasons do student teachers give for choosing the pedagogies they use during teaching practice?
3. What challenges do student teachers face when using the reported pedagogies during their teaching?
4. What pedagogies do student teachers prefer to use but do not use them during their teaching practice?
5. What reasons do student teachers provide for not using the preferred pedagogies during teaching practice?
6. Do student teachers receive any support from the school during their teaching practice?

2. Methodology

2.1 Research design

This study used a descriptive survey research design. This is a type of research design where data are collected by using questionnaires, closed interview questions, or observation. The survey of a given sample describes aspects of a probe into a given situation or state of affairs that exist at a given time.

2.2 Participants

This study was carried out with 106 mathematics and science student teachers from the Copperbelt University. Among the participants were 16 Biology Education students, 11 Chemistry Education students, 64 Mathematics Education students, and 15 Physics Education students. This number comprised 84 males and 22 females. All the participants were in their 3rd year of the 4 years Teacher Education Programme. Table 1 below gives a summary of student teachers' subject specializations.

Table 1: Student teachers' subject specialisations

Subject	Frequency	Percentage
Mathematics	64	60.4
Biology	16	15.1
Physics	15	14.2
Chemistry	11	10.4

2.3 Data Collection Instrument
A questionnaire was used to collect data in this study. The questionnaire focused on the pedagogies student teachers used during teaching practice. The questionnaire was developed by the authors. Experts in the field were used to validate the instrument.

2.4 Data analysis
Data were analysed qualitatively by computing frequencies and percentages.

3. Results
3.1 Pedagogies student teachers use during teaching practice
Student teachers were asked to list any five pedagogies or teaching strategies that they used more often during teaching practice. The results of the pedagogies student teachers used during teaching practice are shown in Table 2 below. From Table 2, it can be seen that group discussion (89.6%) was the most common pedagogy the student teachers used. The other pedagogies commonly used were lecture (73.6%), demonstration (67.9%), Question and Answer (67.0%), and Problem Based Learning (49.1%).

However, role play and peer teaching were the least used pedagogies with one participant each (0.9%) reporting to have used the strategy. The other least used pedagogies were field trip and practice and drill each recording 2 participants (1.9%) to have used them.

Table 2: Student teachers' commonly used pedagogies

Method	Frequency	Percentage
Group discussion	95	89.6
Lecture	78	73.6
Demonstration	72	67.9
Question & Answer	71	67.0
Problem Based Learning	52	49.1
Experimental	21	19.8
Inquiry	18	17.0
Discovery	16	15.1
Teacher Exposition	14	13.2
Cooperative learning	10	9.4
Class discussion	5	4.7
Project	4	3.8
Computer Simulation	4	3.8
Story Telling	3	2.8
Debate	3	2.8
Practice & Drill	2	1.9
Field Trip	2	1.9
Peer Teaching	1	0.9
Role play	1	0.9

3.2 Reasons for choosing the identified pedagogies
Student teachers were asked to provide reasons for using the pedagogies they reported to have used during teaching practice. The results are shown in Table 3 below. For example, participants reported that they used group discussion because it promoted good retention of knowledge, encouraged expression of ideas, encourages sharing of ideas, can be used to assess pre-requisite knowledge, and promotes teamwork and interaction. Similarly, the reasons given for using demonstration method was that it enhances understanding of concepts, lack of adequate equipment, to teach abstract concepts, and conducting risky experiments which the learners cannot do on their own.

Table 3: Suggested reasons for choosing the reported pedagogies

Method	Reasons for using the method	Frequency	Percentage
Group discussion	Encourage teamwork & interaction	44	42
	Encourages sharing of ideas	38	36
	Encourages expression of ideas	20	19
	Assessing pre-requisite knowledge	12	11
	Promotes good retention	4	4
	Improve research skills	4	4
	Encourage critical thinking	4	4
Demonstration	Enhance understanding	24	23
	Lack of adequate equipment	20	19
	Teaching abstract concepts	18	17
	Conduct risky experiments	4	4
	Orienting learners to a task before they do it	2	2
Inquiry	Encourage self discovery	8	8
	Enhance problem solving skills	8	8
	Actively involve learners	6	6
	Exposure to use equipment	2	2
Question & Answer	To keep learners engaged	30	28
	Evaluate understanding	20	19
	To assess pre-requisite knowledge	16	15
	To build on what learners already know	6	6
	Encourage critical thinking	6	6
	For recap	6	6
Lecture	To cover more work	38	36
	Explain concepts	14	13
	To teach abstract concepts	4	4
	Classes are over enrolled	4	4
Problem Based Learning	Enhance problem solving skills	10	9
	Promote critical thinking	8	8
	Sharing knowledge	4	4
Experiment/practical	Enhance understanding of concepts	24	23
	Relate content to real life	4	4
	Labs are well equipped	2	2
	Introduce learners to lab equipment	2	2

3.3 Challenges faced when using the identified pedagogies

Despite the student teachers reporting to have used the pedagogies above, they also reported to have faced some challenges while using these pedagogies. Table 4 below gives a summary of these challenges for each method. For example, group discussion was associated with the following challenges: time consuming, few learners participating, groups were large due to overenrolled classes which later brought up class management challenges.

Table 4: Challenges faced by student teachers when using the identified pedagogies

Method	Challenges	Frequency	Percentage
Group discussion	Time consuming	38	36
	Not all learners participate	26	25
	Groups were large	16	15
	Class management	28	26
	Group members looking down upon others	6	6
Demonstration	Inadequate equipment/materials	24	23
	Large classes	12	11
	Focusing only on the fun part of the demonstration	6	6
Question & Answer	Time consuming	8	8
	Same few pupils participating	14	13
	No adequate participation from learners	12	11
	Learners shy to participate	8	8
Lecture	Understanding of concepts is low	38	36
	Class management challenges	10	9
	Difficult to measure understanding	6	6
Experiment	Lack of adequate equipment	24	23
	Time consuming	2	2
	Pupils damaging apparatus	2	2

3.4 Pedagogies student teachers would have loved to use

Student teachers were also asked to identify pedagogies they would have loved to use but did not use them during teaching practice. Table 5 below gives a summary of such pedagogies. Among the pedagogies the student teachers would have loved to use are field trip (38.8%), computer simulation (31.1%), and experiment (20.8%). However, pedagogies with least percentage of student teachers to have loved to use them are lecture (6.6%), demonstration (5.7%), question and answer (5.7%), role play (5.7%), and group discussion (3.8%). Except for role play, the pedagogies with least percentages also appear among the pedagogies mostly used by the student teachers.

Table 5: Pedagogies student teachers would have loved to use

Method	**Frequency**	**Percentage**
Field Trip	41	38.7
Computer Simulation	33	31.1
Experimental	22	20.8
Inquiry	17	16.0
Debate	15	14.2
Games	15	14.2
Project	13	12.3
Problem Based Learning	12	11.3
Lecture	7	6.6
Demonstration	6	5.7
Question & Answer	6	5.7
Role Play	6	5.7
Group Discussion	4	3.8

3.5 Reasons for not using the preferred pedagogies

Student teachers were asked to provide reasons for not using the pedagogies they would have loved to use during their teaching practice. Their reasons mainly centred on resources such as time, finances, and materials. For example, the reasons they provided for not using computer simulations are lack of resources such as computers, projectors, internet connectivity. Furthermore, some schools have computer labs which are only accessed by computer studies learners. Similarly, experiments were not used because schools either have no labs or have labs with inadequate facilities. Table 6 below gives a summary of the reasons reported by the pre-service teachers for not using the preferred pedagogies.

Table 6: reasons for not using the preferred pedagogies

Method	Challenges	Frequency	Percentage
Computer Simulation	Lack of equipment: computers, projectors, internet connectivity, etc	52	49
	School not connected to power	4	4
	Not simulation software to use	4	4
	Only computer studies learners access the computer lab	6	6
	Faulty electrical installations	4	4
	Difficult to find appropriate simulations	6	6
	School has no computer lab	4	4
Project	Limited time for teaching practice	8	8
	No funding for projects	6	6
	Lack of knowledge on the projects	2	2
Field Trip	Time limitation	12	11
	Lack of resources: e.g. money, transport	40	38
	School calendar fully packed	5	5
	Lack of support	3	3
	Lack of knowledge of where to go	3	3
Inquiry	Time limitation	4	4
	Limited teachers' knowledge on inquiry	3	3
	Lack of equipment	4	4
	Overenrolled classes	4	4
Experiment	No lab equipment/resources	16	15
	The school has no lab	10	9
	Labs only used by exam classes	3	3

3.6 Support received from the school

When asked if they received any support from the schools during their teaching practice, 56.6% of the participants agreed that they received support. The kind of support they received include teaching resources such as books, manila papers, models, chalk etc. (47%), expertise when preparing for the lessons (21%). On the other hand, 43.4% said they did not receive any support. Those that reported that they did not receive any support said they would have loved to receive support such as teaching resources (32%), financial support for field trips (4%), lab chemicals and equipment (5%).

4. Discussion

The purpose of this study was to explore the PCK for mathematics and science student teachers who were on teaching practice. Specifically, the study was conducted to determine mathematics and science student teachers' pedagogies often used during teaching practice; determine mathematics and science student teachers' reasons for the choice of the reported pedagogies; determine the challenges the student teachers encountered when using the reported pedagogies; determine the pedagogies student teachers would have preferred to use during teaching practice but could use them; determine the reasons for the student teachers not use the preferred pedagogies; find out if there was any support the student teachers received from the school where they did their teaching practice.

The results of this study show that group discussion, lecture, demonstration, question and answer, problem based learning, were the most common pedagogies student teachers used during teaching practice. According to the participants, these pedagogies were preferred because they were easy to use, promoted retention of knowledge and they were appropriate to use in a situation where resources such as lab equipment were scarce. Furthermore, the pedagogies were appropriate for the overenrolled classes.

There are various methods available for effective teaching and learning of science. For a method to bring about good results, it must promote social interaction among learners, and between learners and the teacher (Kola & Langenhoven, 2015). Among the effective methods include laboratory, practical work, demonstration, project, guided discovery and inquiry methods (Arubayi, 2015). Although Kagoda and Sentogo (2015) reported that student teachers use appropriate teaching strategies during their teaching practice, some of these pedagogies reported to have been used by the student teachers in this study are not appropriate for the effective learning of mathematics and science. For example, lecture is a more teacher centred approach and does not promote effective learning of concepts (Kola & Langenhoven, 2015). Student teachers often use pedagogies they are familiar with and are convenient to them. However, some pedagogies such as Problem Based Learning, group discussion, and demonstration are learner centred. Such pedagogies keep learners active during the learning process. They are considered appropriate in the midst of challenges such as overenrolled classes and limited resources. Inadequate resources, overenrolled classes, poor class management, limited time were among the challenges student teachers faced while using the reported pedagogies during teaching practice. The challenges reported by the student teachers in this study are similar to those reported in other studies. For example, Nwanekezi, Okoli and Mezieobi (2011) reported that student teachers face challenges such as lack of instructional materials, equipment, and resources. In addition Nwanekezi, Okoli and Mezieobi (2011) also reported challenges such as congested classrooms. The Zambian curriculum is so much examination oriented and overloaded with content such that teachers teach in order to cover the whole content of the syllabus quickly. This is meant to adequately prepare the learners for the competitive national examination. Learners' entry into tertiary institutions of learning is dependent on their performance in the national examinations. This encourages rote learning where learners do not fully understand the concepts being taught. As such, lack of adequate time was reported as one of the challenges student teachers faced. Such a challenge promotes the use of pedagogies such as lecture method which helps cover a lot of content within a short time.

Among the pedagogies student teachers would have loved to use but did not use are field trip, computer simulation, experiments, and inquiry. These pedagogies require both expertise and resources. As such, they ranked high on not being used. Student teachers reported reasons such as lack of equipment, lack of knowledge, limited time, no laboratories or poorly equipped laboratories as the reasons for not using the pedagogies. Literature reports that such pedagogies are effective in teaching science (Arubayi, 2015).

This study also reported that most student teachers received support from the schools where they did their teaching practice. This should be commended as some schools do not provide any support to the student teachers. For example, Msangya, Mkoma and Yihuan (2016) reported that student teachers face challenges such as lack of financial and material support during their teaching practice.

5. Conclusion

This study has shown that mathematics and science student teachers mostly used pedagogies that actively involve learners during lessons. Specifically, they used pedagogies such group discussion, demonstration, question and answer, and problem based learning. Although there could be other more effective pedagogies that actively involve learners, the pedagogies student teachers chose to use were appropriate in a situation where teaching and learning resources are scarce and the classes were overenrolled. In addition, these pedagogies were preferred because they were easy to use and promote good retention of knowledge in the learners. In using these pedagogies, student teachers faced challenges that hinge on inadequate resources and over enrollment. Classroom management was also reported as a challenge emanating from overenrolled classes. Most of the pedagogies that student teachers reported to have preferred to use but did not use them are more learner-centred and keep learners active throughout the learning process. Such pedagogies include field trip, computer simulation, experiments, and inquiry. Due to the reported challenges, most student teachers could not use these pedagogies. In addition, these pedagogies require knowledge of using them which some student teachers reported not to have. The study has also revealed that most student teachers received support from the school where they did their teaching practice.

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