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Analysis of Pedagogical Content Knowledge in Terms of Instructional Strategies of Science Teachers: A Quantitative Study

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ABSTRACT

Aim of the study: The study was conducted to analyze the pedagogical content knowledge in terms of instructional strategies of in-service science teachers inducted by federal directorate of education (FDE) by taking students' perspective. The knowledge of instructional strategies was analyzed with respect to subject specific and topic specific instructional strategies used to teach Biology.

Methodology: By following quantitative approach, students' perspective of their biology teachers' knowledge of instructional strategies was taken. Population of the study comprised of 860 students. 270 pre-medical students of SSC I were selected through random sampling technique by using Morgan table. Data were collected through self-developed questionnaire instrument. Validity was confirmed by experts of the field and reliability was calculated by using Cronbach alpha. Value of 0.090 showed that questionnaire reliability was higher. Data were analyzed through frequencies, percentages, means and standard deviation.

Findings: Data analyzed showed that students had high perspective of their teachers regarding them pedagogical knowledge of instructional strategies used to teach subject and topics of particular subject. However, in case of subject specific instructional strategies, teachers and despite having knowledge of multiple strategies, failed to use them in classroom setting. Instead, they rely on traditional method i.e., lecture method to teach biology. Similarly, in topic specific instructional strategies, teachers failed to facilitate group discussion so that ideas might be exchanged among students.

Conclusion: The study concluded that in-service science teachers need training to facilitate flexible and practical use of both subject specific and topic specific instructional strategies in class.

Keywords: Pedagogical Content Knowledge, Instructional Strategies, Subject Specific Instructional Strategies, Inquiry Based Learning, Topic Specific Instructional Strategies, Lecture Method, Illustrations and Representations.

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1. INTRODUCTION

Science teachers play crucial role in the lives of the students. They are the pivot playing a major role in shaping the students by making complex scientific knowledge more comprehendible and simpler to understand by using different pedagogies. Pedagogical content knowledge is one of the effective tools which enable teachers to reach to the level of students' understanding and bridge the gap between complex content/concepts provided in the text book and students' misconceptions and confusion (Behling et.al., 2022). Thus, it can be inferred that PCK is the type of knowledge which assist teachers to transform subject matter into more comprehendible form of knowledge easy to be grasped its essence by the students. it is one of the chief frameworks widely employed by teachers to integrate content into right pedagogy (Yanti et al., 2020). Researchers (Gess-Newsome and Lederman, 1999; Shulman, 1987) put emphasis and concluded main criterion for successful teaching is to possess a solid knowledge base that includes a blend of content knowledge and pedagogical knowledge. It was first indicated by Shulman in mid-1980's that teacher transformed their knowledge of content to teach in class room context. According to Kang et.al., (2018) pedagogical content knowledge (PCK) is a combination of subject and pedagogical knowledge. Thus, PCK is the capacity of a teacher to relate their knowledge of pedagogy (knowledge of teaching) and knowledge of subject (knowledge of subject matter) and knowledge of context (classroom and school setting).

Model developed by Magnusson et.al., (1999) is one of the most reliable models used to analyze pedagogical content knowledge of science teachers (Ali & Shah, 2021). It consists of different domains like orientation to science teaching, curricular knowledge, knowledge of instructional pedagogies, assessment methods knowledge and knowledge of students' understanding of science. One of the most significant areas that takes all the other areas with it is, instructional strategies. Science teachers when enter in class, have planned lessons and activities to use in class to make lessons more interesting and clearer. They use AV aids and other resources which support them in teaching and demonstrating the concept in the most effective manner. At the end, teachers use assessment methods as tool to assess and evaluate scientific knowledge learnt and understood by the students. For this, teacher needs to have a strong base to effectively use pedagogical instructions to ensure effective learning of the students. However, in-service science teachers inducted by Federal Directorate of Education (FDE) face lot of problems because of lack of expertise in PCK. Lack of pedagogical skills and lack of confidence in implementing multiple instructional strategies in class rooms despite having knowledge of different areas of PCK is one of the major challenges faced by the science teachers as they don't know how to use it in context of class room (Samuel & Dudu, 2021). In other words, it can be said that teachers fail to use instructional strategies in class to make their teaching of science more interesting and effective. A study showed that teachers failed to use their teacher practices effectively to clear misconceptions of students regarding respiratory concepts (Dam et.al., 2019).

Science teachers' knowledge of pedagogical strategies can best be observed by their students and give more clearer picture about the teaching of teachers as teachers enter the class with self-centered thinking because of having authority in the class room. Therefore, when such is the case, students' perspective on the basis of their daily observation of their teachers' teaching may be used as a tool to investigate and analyzed the teachers teaching in science (Senocak, 2009). Thus, PCK can be assessed through students' perspective (Halim, Abdullah & Meerah, 2014). It may be assumed that teachers' PCK in students' perspective is the knowledge of teachers, put in action and observed by students is enacted PCK of teachers.

1.1 Statement of the Problem

The study aimed to analyze PCK of in-service science teachers teaching Biology in terms of instructional strategies at secondary level. The research study analyzed PCK in terms of instructional strategies comprised of subject specific strategies and topic specific strategies used to teach Biology at secondary level by taking perspective of pre-medical students of SSC-1.

Subject specific instructional strategies include broader spectrum of teaching methods used to teach biology for example, inquiry-based learning (IBL), project-based learning (PBL) or discovery learning while, topic specific strategies involve strategies used to teach specific concepts or topics in biology for example, whether teachers use representations, illustrations or hands on activities to teach biology concepts.

1.2 Significance of the Study

This research study benefits the in-service science teachers teaching biology. By taking students' perspective, teachers were provided with the opportunity to reflect upon their own teaching and may improve their teaching practices according to needs of the students.

1.3 Objectives of the Study

Following objective and sub-objectives were formulated for the study.

a. To analyze pedagogical content knowledge of in-service science teachers teaching biology at secondary level in terms of instructional strategies.

i. To analyze subject specific instructional strategies of in-service science teachers teaching biology at secondary level.

ii. To analyze topic specific instructional strategies of in-service science teachers teaching biology at secondary level.

1.4 Research Questions of the Study

Following research questions were formulated for the study.

a. To what extent in-service science teachers possess knowledge pedagogical content knowledge of instructional strategies at secondary level?

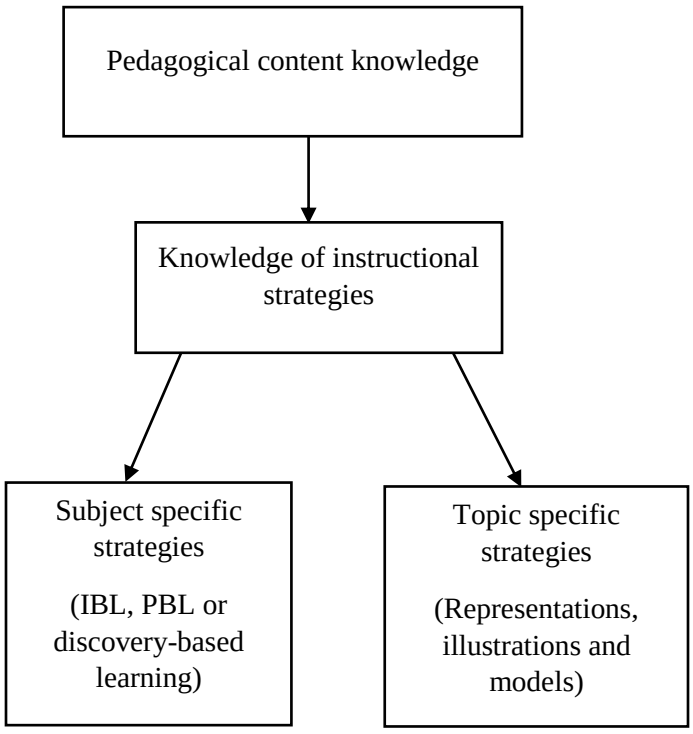
i. To what extent in-service science teachers possess knowledge of subject specific instructional strategies?

ii. To what extent in-service science teachers possess knowledge of topic specific instructional strategies

1.5 Conceptual Framework of the Study

Knowledge of Instructional strategies is one of the areas which is shaped and influenced by PCK. Knowledge of instructional strategies includes both subject specific strategies and topic specific strategies. Subject specific strategies are broader in context like inquiry-based learning, discovery learning etc. while topic specific strategies are narrow category to teach a single concept either through representation, activities, illustration or models (Usak et al., 2022).

Figure 1: *Conceptual framework of the study*



2 LITERATURE REVIEW

2.1 Origination of pedagogical content knowledge

Pedagogical content knowledge is originated in mid 1980s and the idea was developed by Shulman who defined it as a knowledge used to guide teachers and assist them to transform content knowledge into more understandable knowledge thus, making teaching-learning process effective. This knowledge was later called as pedagogical content knowledge (Buma & Sibanda, 2022). This knowledge enables the teachers to make knowledge accessible to students by transforming into more comprehensible content which would otherwise be difficult to be understood by the students.

According to a study, pedagogy and subject both are necessary and crucial in transferring content knowledge into teaching practice (Jacobs et.al., 2019).

2.2. Pedagogical content knowledge and in-service science teachers in Pakistan

In-service science teachers mostly rely on traditional teaching methods to teach sciene subjects like, lecture method and students used to cram concepts without understanding their explicit meaning. In-service science teachers though, have knowledge of content but they do not undertake contemporary issues in science subjects to make their teaching applicable to real life situations. In-service science teachers are facing critical challenges in implementing their pedagogical content knowledge in class-room setting in context of Pakistan. In-service science teachers persistently rely on traditional science teaching and mainly use “chalk and talk” or “reading and translating text” model. In contrast, science subjects are taught through inquiry across the globe, developing the skills of creativity, critical thinking, communication and collaboration (Ali, 2023).

2.3. Instructional strategies employed by in-service science teachers

A science teacher is a change agent who has skills to transforms ideas and content provided in text books into an interesting comprehendible knowledge thus, making concepts easy and simple. Thus, A competent and committed teacher is in demand to bring a revolution only if she/he knows how to convert content knowledge into an activity, practical experience or an observable phenomenon through employing pedagogical strategies (Lucero, 2021). Instructional strategies include all those strategies which are used to teach science subjects and topics in the science. According to Magnusson et.al., (1999) model knowledge of instructional strategies implies both subject bases instructional strategies for example, inquiry-based learning, project-based learning or problem-based learning and topic bases strategies employed representations and activities. These instructional strategies are more student friendly strategies thus, can be called students centered approaches. Student-centered approaches encourage the students to direct their own learning and give them confidence to work with other students on research projects and assignments culturally and socially relevant to them. These make students self-confident, self-directed, and proactive where teacher's primary role is to coach and facilitate student to learn the concepts explicitly (Lucero, 2021).

2.3.1. *Professional development of pedagogical content knowledge of in-service science teachers in terms of instructional strategies*

In Pakistan, in-service training curriculum is not well aligned with the needs and demands of the teachers and such programs are mostly theory oriented. Another weakness of PD activities is, there is no proper follow-up of these to be transferred to classroom practices (Demir & Qureshi, 2019). Nonetheless, FDE training wing conducts training named as "induction training" which provided training to freshly recruited in-services science teachers in different cadres of subjects at different levels of schools and college i.e., primary, elementary, secondary and higher secondary. This training includes professional teaching knowledge which covers different areas of pedagogical content knowledge. Instructional strategies are one aspect of this induction training in which different strategies are discussed and provided with examples and experiences of teachers. Different modules are designed to assess the knowledge of teachers regarding their pedagogical knowledge in terms of teaching methods. Teachers need to understand the fact that their proficiency in number of different teaching strategies will improve their pedagogical knowledge which they can apply in class room practices. Another important thing to be remembered is, one strategy might not work and could be fit for all classes or students thus, teacher should be smart enough to know which strategy as a tool to be used to effectively teach science subject and topics of a particular science subject.

Another training program was initiated by elementary and secondary education department in Khyber Pakhtunkha (KPK) and implemented by provincial institute of teacher education (PITE). This training program was introduced to train newly inducted teachers for subjects of Science, Mathematics and English. This induction training lasted for six months and its focus was on pedagogical knowledge and teaching practices for specified subjects. It resulted in changing the perception of freshly inducted teachers and they understood that if their pedagogical content knowledge is sound then students understanding and higher order thinking can be made better (Choudhary et.al., 2021).

Thus, it can be concluded that professional development of in-service science teachers is highly needed on continual basis and crucial in terms of instructional strategies as one of the significant aspects of pedagogical content knowledge. In-service science teachers' knowledge of both subject based and topic based instructional strategies is not enough. Science teachers must understand it is beneficial only if they know how to use this knowledge effectively in class. Only then science teachers would be able to effectively process their teaching skills.

3. RESEARCH METHODOLOGY

3.1. Research Approach and Design

Quantitative research approach was adopted to conduct the research in order to analyze pedagogical content knowledge in terms of instructional strategies of in-service biology teachers at secondary level. Research design adopted to achieve objective of the study was descriptive survey design.

3.2. Population of the Study

Population of this study was comprised of 860 pre-medical students of SSC-I.

3.3. Sample of the Study

Sample was comprised of 270 pre-medical students of SSC-1 as respondents of the study. The random sampling technique was used to select sample of study by using Morgan table.

3.4. Data Collection

A self-developed questionnaire was used to collect data from respondents. Content and face validity of the instrument was obtained through experts in field of educational sciences. Reliability of questionnaire was calculated using Cronbach alpha. Obtained value for questionnaire was 0.90 indicating high level of reliability.

3.5. Data Analysis

Data collected through survey questionnaire were analyzed by using SPSS version 25. Survey questionnaire was comprised of total 21 items for analyzing pedagogical content knowledge in terms of instructional strategies. 1 to 11 items were for analyzing subject specific strategies while 12 to 21 items were for analyzing topic specific strategies. Data were analyzed by calculating frequencies, %ages, means and standard deviation.

4. RESULTS

4.1. Knowledge of Subject specific instructional strategies

Table 1 shows responses of respondents about knowledge of subject specific instructional strategies. Subject specific instructional strategies included those strategies which might be used by teachers to teach biology to make it more understandable and comprehendible for example, inquiry-based learning, project-based learning or discovery learning. As shown in table, responses were analyzed through calculating frequencies (percentages), means and standard deviation. Frequencies and percentages showed number of respondents who agreed, disagreed or could not understand the items on 5 Likert scale. Majority of the respondents agreed on the items related to subject specific instructional strategies. For instance, respondents agreed to the statement that their teachers have knowledge of multiple teaching strategies used to teach biology (61.9%, M= 4.25 and SD= 0.68) and are well aware of choosing suitable strategy accordingly (45.9%, M= 4.28 and SD= 0.68). Similarly, respondents agreed on use of hands-on activities by teachers (39.3, M= 3.83 and SD= 1.17). Moreover, respondents strongly agreed when they were asked to rate their teacher on using white/black board to illustrate topics of biology (61.1%, M= 4.54 and SD= 0.68). However, majority of respondents also agreed that their teachers use mostly lecture method to teach biology (45.2%, M= 4.16 and SD= 1.008) despite having knowledge of multiple strategies to teach biology. Thus, it can be concluded from the analysis that respondents rated their teachers high in terms of having knowledge of subject specific instructional strategies though, practically they rely more on lecture method and seemed to not having enough confidence to practice different teaching strategies practically in their class room settings.

Table 1: *Teachers' knowledge of subject specific instructional strategies*

Items	SA %	A %	UD %	D %	SD %	M	Std. div
My teacher possesses knowledge of multiple teaching strategies to teach biology.	94 (34.8)	167 (61.9)	1 (0.4)	4 (1.5)	4 (1.5)	4.27	0.68
My teacher is well acquainted with choosing suitable teaching strategy	121 (44.8)	124 (45.9)	12 (4.4)	7 (2.6)	6 (2.2)	4.28	0.68
My teacher uses different resources to teach topics of biology.	75 (27.5)	102 (37.8)	21 (7.8)	57 (21.1)	15 (5.6)	3.61	1.24
My teacher teaches biology through different hands-on activities.	92 (34.1)	106 (39.3)	17 (6.3)	45 (16.7)	10 (3.7)	3.83	1.17
My teacher modifies his teaching according to the situation.	104 (38.5)	120 (44.4)	10 (3.7)	30 (11.1)	6 (2.2)	4.05	1.03
My teacher uses mostly lecture method to teach bology.	122 (45.2)	107 (39.6)	10 (3.7)	26 (9.6)	5 (1.9)	4.16	1.008
My teacher explains topic by writing it on white board.	165 (61.1)	95 (35.2)	3 (1.1)	5 (1.9)	2 (0.7)	4.54	0.68
My teacher used inquiry-based learning method to simplify topic.	148 (54.8)	96 (35.6)	9 (3.3)	13 (4.8)	4 (1.5)	4.37	0.87
My teacher asks questions to check understanding developed by students about a concept.	105 (38.9)	121 (44.8)	15 (5.6)	19 (7)	10 (3.7)	4.08	1.02
My teacher uses demonstration method to teach a concept in biology.	94 (34.8)	127 (47)	13 (4.8)	33 (12.2)	3 (1.1)	4.02	0.99
My teacher keeps students engaged students by involving them in discussion.	98 (36.3)	122 (45.2)	16 (5.9)	30 (11.1)	4 (1.5)	4.03	1.001

Note: n=270, SA= Strongly Agree, A=Agree, UD=Undecided, D=Disagree and SD= Strongly Disagree.

4.2. Knowledge of topic specific instructional strategies

Table 2 presents and illustrates responses on teachers' knowledge of topic specific instructional strategies. Topic specific instructional strategies comprised of teaching strategies used to teach specific topic within subject of biology for instance, representations, illustrations, models and diagrams. Like in table 1, table 2 also shows agreement, disagreement and undecided responses of respondents on 5 Likert scale. This table mentions responses by calculating frequencies (percentages), means and standard deviation. For example, respondents agreed to greater extent about using diagrams by teachers to explain topics in biology (57%, M= 4.36 and SD= 0.95). However, in case of using physical models to teach human systems like, digestive and circulatory system, respondents showed mixed responses though, agreeing more on it (34.4%, M= 3.43 and SD= 1.41). Disagreed respondents show fair enough number with respect to use of

physical models (16.3%, M= 3.43 and SD= 1.41). Respondents also disagreed that their teachers facilitate group discussion among students to exchange ideas among groups (30.4%, M= 2.81 and SD= 1.42).

It can be concluded from above analysis that respondents agreed on most of the statements that their teachers possess good knowledge of topic specific instructional strategies but fail to implement some strategies for example, dividing students in to groups, to make their teaching effective.

Table 2: *Teacher's knowledge of topic specific instructional strategies*

Items	**SA %**	**A %**	**UD %**	**D %**	**SD %**	**M**	**Std. div.**
My teacher illustrates topics of biology through diagrams.	154 (57)	88 (32.6)	10 (3.7)	9 (3.3)	9 (3.3)	4.36	0.95
My teacher asks students to present key points of the topic taught in class.	78 (28.9)	116 (43)	22 (8.1)	39 (14.4)	15 (5.6)	3.75	1.17
My teacher explains systems in humans through physical models.	74 (28.9)	93 (34.4)	19 (7)	44 (16.3)	40 (14.8)	3.43	1.41
My teacher makes flow charts on board to explain processes in biology.	151 (55.9)	94 (34.8)	7 (2.6)	14 (5.2)	4 (1.5)	4.38	0.88
My teacher keeps students curious by asking probing questions.	147 (54.4)	88 (32.6)	9 (3.3)	16 (5.9)	10 (3.7)	4.28	1.03
My teacher relates the concept of biology with real life situation.	131 (48.5)	104 (38.5)	8 (3)	23 (8.5)	4 (1.5)	4.24	0.96
My teacher acts as a facilitator to promote independent learning of students.	84 (31.1)	133 (49.3)	14 (5.2)	25 (9.3)	14 (5.2)	3.91	1.09
My teacher asks students questions to connect different concepts of biology.	96 (35.6)	134 (49.6)	8 (3)	22 (8.1)	21 (7.8)	4.05	1.02
My teacher encourages students to interpret the topic according to their understanding.	66 (24.4)	115 (42.6)	21 (7.8)	47 (17.4)	10 (3.7)	3.58	1.24
My teacher facilitates group discussion in order to exchange ideas among students.	38 (14.1)	77 (28.5)	12 (4.4)	82 (30.4)	61 (22.6)	2.81	1.42

Note: n=270, SA= Strongly Agree, A=Agree, UD=Undecided, D=Disagree and SD= Strongly Disagree.

5. FINDINGS AND DISCUSSION

The findings of the study revealed that teachers, despite having knowledge of different teaching methods, rely more on lecture method to teach topics of biology. This finding shows consistency with previous studies conducted and discovered lack of confidence among teachers to use different instructional strategies to teach science subjects (Aydin & Turhan, 2023; Barendsen & Henze, 2019). It was also found

that teachers check previous knowledge by asking questions about the concept before introducing it to class which showed uniformity with other study also demonstrating on asking questions to check prior knowledge of students (Rauf, Parveen & Naz, 2021). Another finding revealed by this study was applying concepts by teachers through demonstration which is similar to another previous studies (Irmak, Seyma & Yilmaz, 2024).

Findings related to topic specific instructional strategies showed that teachers use models to explain the topics in biology. This finding is found consistent with the previously conducted study which showed higher percentage of teachers teaching biology using models (Sadler et al., 2021). It was also revealed in the findings that teachers ask questions from students to gain understanding concepts of biology. This finding is again found consistent with a past study in which it was discovered that students were provided opportunities to discuss concepts by introducing ideas (Ali & Shah, 2021).

6. CONCLUSION AND RECOMMENDATIONS

Study findings revealed that in-service biology teachers have good knowledge of instructional strategies which are being used by majority of teachers in class. Thus, it may be concluded by looking at findings that respondents have high perspective of their teachers about having knowledge of instructional strategies both subject specific and topic specific. However, teachers do feel little problem to apply the knowledge in the class room settings and relied more on direct method of teaching i.e., lecture method and follow more teacher centered approach. Similarly, it is also concluded that teachers possess knowledge of instructional strategies but somehow failed to practice these in classroom setting which may be improved and enhanced through training sessions. On the basis of these conclusions, following recommendations are made.

1. Students' detailed perspectives may be taken by using qualitative methods, like interviews, in order to explore science teachers' PCK in terms of instructional strategies.
2. In-service science teachers may be provided with effective training programs to make them able to adopt contemporary instructional strategies over traditional or direct teaching methods.
3. Qualitative research techniques like detailed interviews of in-service science teachers and classroom observations may assist the future researchers to explore the gaps in the PCK of in-service science teachers.

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Conflict of Interest

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