FACTORS AFFECTING PEDAGOGICAL CONTENT KNOWLEDGE IN PHYSICS AMONG PROSPECTIVE TEACHERS AT SECONDARY LEVEL IN KERALA

Thesis

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DECLARATION

I, M P Ravishanker, do here by declare that this thesis entitled 'FACTORS AFFECTING PEDAGOGICAL CONTENT KNOWLEDGE IN PHYSICS AMONG PROSPECTIVE TEACHERS AT SECONDARY LEVEL IN KERALA' is a genuine record of research work done by me under the supervision of Dr MUMTHAS N S, Associate Professor, Farook Training College, Research Centre in Education, University of Calicut and that no part of the thesis has been presented earlier for the award of any Degree, Diploma or Associateship in any University.

Place: Farook College M P Ravishanker

Date

CERTIFICATE

This is to certify that the thesis entitled 'FACTORS AFFECTING PEDAGOGICAL CONTENT KNOWLEDGE IN PHYSICS AMONG PROSPECTIVE TEACHERS AT SECONDARY LEVEL IN KERALA' is an authentic record of research work carried out by M P Ravishanker , for the degree of Doctor of Philosophy in Education, Farook Training College, Research Centre in Education, University of Calicut, under my supervision and guidance and that no part thereof has been presented before any other Degree, Diploma, or Associateship in any other University.

The thesis is revised as per the modifications and recommendations reported by the adjudicators and resubmitted.

Dr MUMTHAS N S
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CONTENTS

Chapter	Title	Page
I.	Introduction	1 – 26
II.	Review of Related Literature	27 – 96
III.	Methodology	97 – 140
IV.	Analysis	141 – 230
V.	Summary and Findings	231 – 243
VI.	Conclusion and Recommendations	244 – 256
	References	257 – 274
	Appendices	

LIST OF TABLES

Table No.	Title	Page No.
1	Dimensions and Number of Items of PCK Test (Draft)	107
2	Data and Results of Item Analysis of PCK Test	108
3	Dimensions and Number of Items of PCK Test	111
4	Category Wise Distribution of Items Under Pre-Internship Learner Engagement.	115
5	Category Wise Distribution of Items Under Opportunity to Achieve Learning Objectives	116
6	Category Wise Distribution of Items Under Opportunity to Learn Skills	118
7	Data and Result of Item Analysis of Curricular Experiences Rating Scale	121
8	Dimension-wise Distribution of Curricular Experiences Rating Scale (Final)	123
9	Dimension Wise Distribution of Items in Scale of Attitude Towards Science	126
10	Dimension Wise Distribution of Self-Efficacy Scale.	127
11	Dimension Wise Distribution of Items in Scale of Teacher Motivation	128
12	Data and Result of Item Analysis of Scale on Motivational Factors in Science Teaching	130
13	Distribution of Items in Scale on Motivational Factors in Science Teaching	132
14	Test-Retest Reliability and Cronbach's Alpha Coefficient for Scale on Motivational Factors in Science Teaching	133
15	The breakup of the Intended Sample	134
16	Break up of Final Sample	135
17	Statistical Constants of Scores of Pedagogical Content Knowledge in Physics (total and component-wise) [N=633]	144
18	Statistical Constants of Scores of Select Institutional and learner Related Variables (total and component-wise) (N=633)	147

Table No.	Title	Page No.
19	Mean Scores of Pedagogical Content Knowledge in Physics (total and component-wise) Among Prospective Secondary School Teachers	150
20	Percentile Scores of Pedagogical Content Knowledge in Physics Among Prospective Secondary School Teachers	151
21	Mean Scores of PCK in Physics Among Prospective Secondary School Teachers Based on Relevant Sub-Groups	152
22	Mean Scores of Select Institutional and learner Related Variables Among Prospective Secondary School Teachers (N=633)	155
23	Mean Scores of Select Institutional Learner Related Variables Among Relevant Sub-Groups	156
24	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics (N = 633)	159
25	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics based on Gender.	162
26	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective Secondary School Teachers who have done Graduation with Physics as Main Subject (BSc Physics) (N = 151)	169
27	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective secondary school teachers who have post-graduation in Physics (M.Sc Physics) (N = 171)	171
28	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective secondary school teachers who have done graduation with Physics as a subsidiary subject (N = 275)	173
29	Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among prospective secondary school teachers who have studied Physics only up to class 12 (N = 36)	175
30	Test of Significance of Difference Between Coefficient of Correlation Between the Relevant Sub-groups based on Level of Physics Studied	177

Table No.	Title	Page No.
31	Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables	184
32	Tolerance Level, Variation Inflation Factor and Durbin Watson’s d of the Predictor Variables	185
33	Model Summary of Multiple Correlation Coefficient for PCK in Physics	186
34	Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics	187
35	Beta Coefficients, Coefficients of Correlation and their Products Showing Relative Efficiency of Predictor Variables	190
36	Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables for Prospective Secondary School Male Teachers	196
37	Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables for Prospective Secondary School Female Teachers	197
38	Tolerance Level, Variation Inflation Factor and Durbin Watson’s d of the Predictor Variables	198
39	Model Summary of Multiple Correlation Coefficient for PCK in Physics based on Gender	199
40	Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics based on their Gender	200
41	Correlation Matrix of the Dependent Variable with the Predictor Variables for BSc Physics Group	210
42	Correlation Matrix of the Dependent Variable with the Predictor Variables for MSc Physics Group	211
43	Correlation Matrix of the Dependent Variable with the Predictor Variables for the Subsample who studied Physics as Subsidiary	212
44	Correlation Matrix of the Dependent Variable with the Predictor Variables for the Subsample who studied Physics up to 12th level	213
45	Tolerance Level, Variation Inflation Factor and Durbin Watson’s d of the Predictor Variables	214

Table No.	Title	Page No.
46	Model Summary of Multiple Correlation Coefficient for PCK in Physics based on Level of Physics studied	215
47	Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics	217

LIST OF FIGURES

Figure	Title	Page No.
1	Outline of the Total Procedure.	101
2	Smoothed Frequency Curve of PCK in Physics (total and component-wise)	146
3	Mean Percentage Scores of Select Institutional and Learner Related Variables	157
4	Scattergram of Select Institutional and Learner Related Variables and PCK in Physics	181
5	P-P Plot of Regression Standardised Residual	183
6	Scattergram of Select Institutional and Learner Related Variables and PCK in Physics	192
7	P-P Plot of Regression Standard Residual for Male and Female	195
8	Scattergrams of Select Institutional and Learner Related Variables and PCK in Physics	206
9	P- P plot of Regression Standardised Residuals	209
10	Mean Percentage Score of PCK in Physics	236
11	Mean Percentage Score of Components of PCK in Physics (Sub-groups)	236

In India, achieving scientific literacy has become a major goal in science education since independence. In the 1990s, scientific literacy was the single term expressing the purposes of science education. The aim of science education is not just to make learners aware of the scientific facts and concepts but to make people aware of the benefits of using scientific thinking in personal and public life. Dissemination of scientific values is an integral part of the educational process of learning science. It is essential to have a scientific mind as it helps to participate in democratic decision-making in both personal and public life.

In the Indian education system, it is essential to develop an innovative approach to teaching science to promote understanding of science as a process that helps learners deal with significant problems in their lives. The attributes of science viz., rationale, creativity, critical thinking and scientific worldviews are universal values. These values are essential for the growth of an individual and society as a whole. As the world becomes increasingly reliant upon science, technology, engineering and mathematics, there is genuine concern about the quality and effectiveness of science education in India. Thus, there is a growing concern over making our citizens scientifically literate to know the various science products and, more importantly, understand science itself. When students fail to develop a basic understanding of scientific concepts and the processes and methods of science, they perceive science as separate from their lives. Lack of scientific literacy is especially troubling in a world increasingly reliant upon science and technology; thus, the scientific literacy of every Indian citizen is of great concern.

The receptivity and retention of scientific information within peoples' structure of thought reduce as the distance of a scientific area, phenomenon or experiential episode from their quotidian life increases. As far as the average Indian is concerned, due to the absence of a sufficiently broad scientific knowledge base, they fall back on extra-scientific structures of thinking for seeking explanations of natural phenomena. Hence, they cannot be categorized as mythical or superstitious. India must significantly increase the scientific and mathematical competency among secondary school students to ensure an adult population capable of understanding and reaching consensus on policies addressing the socio-political problems that we face in everyday life. Concerns about the quality and effectiveness of science education in India are mounting as Indian youth fall behind their international peers in other nations in terms of knowledge of science and technology. Within the broad umbrella of human capital, the role of scientific manpower or Human Resource in Science and Technology (HRST) is critical, and there is a close relationship between HRST and economic growth. Human capital is the only form of capital that has the ability to modify itself and other inputs and, therefore, possesses the capacity to create a new and developed country.

It is important to note that in 2015, the percentage enrolment in various disciplines at the undergraduate level in higher education like engineering and technology, science and medical science was 15.57, 16.04 and 3.30, respectively

(MHRD, 2018). This trend should be addressed because 15 of the 20 fastest-growing occupations projected for the 21st century require significant science and mathematics knowledge. Students develop their attitudes toward science and their understanding of science throughout their secondary school educational experiences. Teachers control the learning environment and ultimately determine what is taught, when it is taught, and how it is taught. To be effective and successful, teachers at the school level handling science subjects must have strong subject matter knowledge, understanding of the nature of science, capacity to transform subject matter knowledge into meaningful learning experiences for students based on the context of learning, and highlight importance of science within society and in the lives of students (NCF, 2005). Teachers are a critical factor in student learning. Hence, teachers must be at the centre of the fundamental reforms in the education system. The education system should focus on helping re-establishing teachers, at all levels, as the most respected and essential members of our society because they truly shape our next generation of citizens. We have to do everything to empower teachers and help them to do their job as effectively as possible.

Need and Significance of the Study

Education commissions in India since independence have coherently recommended science teachers who actively engage students in a way that equips them to: apply scientific principles and processes to decision making; understand the natural world; and consider careers in science, technology, engineering, or mathematics (NEP, 2020). The Education Commission (1964-66) recommended the professionalisation of teacher education, development of integrated programmes, comprehensive colleges of education and internship. The National Commission on Teachers (1983-85) recommended five-year integrated courses and internship. Teacher education is supposed to provide prospective teachers with the means to meet the challenges they are likely to face in their teaching careers.

The National Policy on Education (NPE,1986) recommended the overhaul of teacher education to impart a professional orientation. Therefore, the education of teachers is commonly considered a crucial factor for securing the quality of science education.

Science education has seen its share of reform efforts come and go. The locus of these reforms has been changes in science curriculum and instruction. Presently we are amid yet another wave of reform sparked by the publication of science standards in several countries. This time, however, the reform efforts are attending to a feature of reform that has often been sidelined, i.e., the science teacher education. Reformers have realized that new curricula or innovative instructional techniques need teachers to carry them out. Thus, focusing on reform in science teacher education will be crucial to the success of other science education reforms.

National Curriculum Framework for Teacher Education (NCFTE, 2009) recommends urgent and comprehensive reforms in Teacher Education and puts forward the need to bring greater convergence between professional preparation and continuing professional development of teachers at all stages of schooling in terms of level, duration and structure. All these recommendations point out the need to fill the gap between the dual nature of teacher knowledge, the knowledge base for teaching and the knowledge base of teaching. Hence, in teacher education, there should be a conscious effort to synthesize all types of teacher knowledge, viz., practical knowledge, personal knowledge, personal practical knowledge, professional knowledge, the wisdom of practice and teachers' professional knowledge, into a comprehensive and definable whole.

The National Policy on Education (NPE, 1986) describes effective science learning as occurring when learners actively engage with science, making connections between scientific concepts, applying their knowledge of science for solving everyday problems, supporting claims with evidence, and reflecting upon their methods, processes, and conclusions. This description of science learning requires that science teachers have a deep and flexible understanding of science subject matter and scientific concepts, as well as an understanding of students as learners, knowledge of instructional strategies, representations, assessment strategies, and curricular resources (Darling-Hammond, 2008). The goal of science teacher education is to provide future teachers with the 'intellectual tools' to further develop over the course of their careers.

The curiosity about Pedagogical Content Knowledge (PCK) as a research topic originated during the researcher's tenure as an optional teacher of physical science in a teacher training college. The research programme by Loughran, Berry and Mulhal (2012) on the PCK of science teachers greatly influenced the investigator in the early stage of this study. As a teacher educator, while observing the practice teaching by student teachers during their internship programme, the researcher came to witness their struggle in classrooms even after adequate planning and preparation.

This made the researcher think that PCK is a necessity for effective teaching, and helping prospective science teachers develop PCK is the need of the hour.

Abell (2008) noted that “understanding the development of teacher subject matter knowledge and Pedagogical Content Knowledge (PCK) is critical for our success in science teacher education”. Evidently, it has been in the hands of science teacher educators to provide insight into the what, why, and how of teaching for prospective and novice teachers. Several studies have examined changes in preservice teachers’ science instruction during their first year in the programme.

Abell (2008) conceptualizes PCK as having four important characteristics: (i) PCK includes distinct categories of knowledge used coactively during teaching, (ii) PCK is dynamic and continually changing as teachers gain teaching experience, (iii) knowledge of the subject matter and (iv) transformation of subject matter knowledge into a form of knowledge understandable for students. PCK is not only about knowledge the teacher possesses. It is also highly reflective of the quality of teacher knowledge, teaching experience, and the manner in which the components of PCK are integrated to create effective learning experiences. PCK based teacher education can become an effective tool in making novice teachers access the so-called tacit behaviour of expert and effective teachers.

Preservice teachers’ competency in science teaching can be summarized into three aspects, how they represented concepts, how those representations reflected the needs of learners, and how they managed participation, resources, and time in the service of content representation. Teacher education coursework has to focus mainly on teacher competency giving due weightage to content and pedagogy. The present teacher education programmes in their course work do not give adequate stress on subject matter knowledge or content knowledge. Maybe it is expected that student teachers acquire subject knowledge for teaching from their university courses. Subject matter knowledge is very important in the development of PCK and in valuing teacher competence.

Schwab (1971) described teacher knowledge in practical terms as the wisdom of practice developed through classroom experience. Feiman-Nemser (2001) notes that knowledge for teaching develops with experience as teachers learn to blend their knowledge of students as learners with their knowledge of content to make concepts understandable. Teacher knowledge is closely related to individual experiences and contexts and, therefore, unique to the individual. Successful teachers are able to transform their knowledge of scientific concepts into a form of knowledge that can be understood by learners by integrating their knowledge of learners, representations, instructional strategies, assessments, and curricular resources to create meaningful learning opportunities that make connections between lesson content and students' experiences (Shulman, 1987).

The goal of teacher preparation has to be to promote effectiveness and teaching competency in student teachers. To be effective, teachers need to have good knowledge about students' previous knowledge and be able to activate essential prior knowledge, understand possible difficulties and errors that learners will develop during learning, adjust teaching approaches and strategies to cater to diverse student learning needs, make meaningful connections between concepts, identify relevant connections between content and student lives, given ample opportunities for students to assess their learning, use feedback on formative assessments to inform instruction, and ability to understand and follow instructional goals and methods best suited for the topics being taught. The duration and approaches in teacher education for producing efficient teachers definitely matter on the length of academic preparation and quality of course work that we incorporate in the whole programme.

Teacher preparation needs to focus on pre-service teachers' ability to assess students' prior knowledge and design learning experiences to promote cognitive development, management of participation, resources, and time. All of these either facilitate or inhibit teachers' capacity to make the content comprehensible for the students. Novice teachers are disappointed with their teacher education programmes. Present teacher education programmes barely cater for the expectations of student teachers, where they expect they will be told how to teach and instead, they are presented with enormous numbers of teaching issues to consider, which readily don't translate into how to conduct a lesson. This invokes a perception commonly in student teachers that 'theory is irrelevant in learning to teach', which becomes a real barrier in 'learning to teach'. Teacher education programmes fail to integrate theory and practice in teaching, which has been a major cause of disappointment among student teachers. In order to make prospective teachers fully prepared for diverse learning situations with good subject matter knowledge and pedagogical skills, teacher education needs more emphasis than mere training and should provide relevant knowledge, attitude and skills to develop as professional teachers.

In order to know how to educate future teachers, we should deeply understand what all factors in teacher education contribute to each area of pre-service teacher's professional knowledge. The primary purpose of teacher preparation is to help prospective teachers integrate knowledge bases in planning for instruction (Shulman, 1987). The teacher education structure should have enough opportunities for student teachers to understand what all elements will mould them into expert teachers. There should be ample space in the curriculum to explore diverse sources of knowledge of content, representations of content, pedagogy, curriculum and learners that teachers draw on in teaching. Shulman and his colleagues point to the important role of subject matter knowledge in effective science teaching: however, subject matter knowledge in and of itself is not sufficient.

New teachers have to develop pedagogical content, knowledge of the most effective ways to teach various concepts, and knowledge of curriculum, learners/learning and instruction. Novices need to develop representations (e.g., examples, explanations, metaphors, investigations) that can be adapted to the diverse interests and abilities of learners. Pedagogical content knowledge of teachers helps in the learning progression of students via meaningful interception of their conceptions and misconceptions in both product and process aspects of science. This capacity to transform subject matter knowledge into forms that are pedagogically powerful and adaptive to particular groups of students is at the core of successful science teaching.

Prospective teachers lack specialized knowledge for teaching (Grossman, 1990; Magnusson, Krajcik & Borko, 1999; Shulman, 1987) and, as a result, rely upon their own experiences as learners during planning and teaching. The structure of the teacher preparation programmes and the means used is the main cause of this problem. This can be solved to a great extent by implementing mentorship in teacher education, where the mentor will be an expert, efficient and competitive teacher with adequate experience. The role of the mentor teacher is to reveal prospective teachers' thinking and stimulate critical analysis of their ideas about teaching, learning, and learners, ultimately making connections between lesson content, appropriate representations, instructional strategies, curricular sequence, and assessment. The mentor teachers need to implement strategies to reveal prospective teachers' conceptions of teaching, learning, and learners and to identify and address potential difficulties with learning to teach.

It is commonly said, the main factor in teacher education that promotes teacher knowledge is practice teaching or internships that student teachers undergo during the programme. As pre-service teachers' knowledge and experience increase, the interaction between their knowledge of learners and knowledge of instructional excerpts becomes more integrated. Pedagogical content knowledge of novice teacher will enhance when they get in close contact with the real school environment. Pre-service teachers' limited practical knowledge of classrooms, however, has been implicated as an underlying reason for difficulties preparing and implementing powerful representations of content (Kagan, 1991). Although student teachers have a wealth of experience as learners in classrooms, they have minimal experience orchestrating classroom activities. Appropriate course work on PCK in teacher education institutions will make a very evident change in student teachers' thinking about planning for teaching as they will be absolute in making links between teaching and learning as opposed to simply delivering prescribed content. PCK is an essential variable for teachers in applying teaching approaches that are in harmony with the principles underlying the ongoing educational reforms. Student teachers with integrated teacher knowledge of theory and practice of teaching will be more effective in their teaching careers.

The present scenario in schools is that experienced teachers do know what he/she is doing, but he/she does not realise he/she has PCK, he/she just does it. They are not familiar with the construct PCK. They say, ‘when I get to this topic when I get to this point, they’re not going to get this, and this is how I get around it,’ and they are very much aware of it. When the student teachers are sensitized by the idea of PCK, they will be very much able to identify the contributions of PCK in better planning for teaching and learning. They will be able to find out the elements of PCK in experienced teachers’ practice and will be able to incorporate it themselves. Understanding pedagogical content knowledge as a construct can change what student teachers see in their mentor’s practice, developing more sophisticated ways of thinking about and conceptualising their understanding of teaching science.

Formal learning opportunities from teacher education institutions play an essential role in shaping the PCK in novice teachers. This is mainly related to the objectives of the programme. Formal learning should match the intention of the student-teacher, which is to acquire knowledge and skills. At the same time, the informal learning opportunities that student teachers receive from teacher education programmes also contribute to the development of different domains of teacher knowledge, especially pedagogic content knowledge. PCK has been successfully established as an educational theory in the last three decades. It has been studied in the perception of content knowledge, pedagogical knowledge and integration of both, but very rarely it has been studied how good the structure of teacher education programmes contributes to its development. In a teacher education programme, student teachers have various opportunities to strengthen their teaching, develop new skills, generate new experiences, and build morals and values; these experiences vary between institutions. Teacher education course work with formal, informal and non-formal learning must be in line to develop the professional knowledge of student teachers from the beginning itself.

PCK development is not always a one-directional process of directly converting existing subject matter knowledge into PCK. The transformation of subject matter knowledge is more of a communication between pre-service teachers' conceptions of subject matter and appropriate pedagogy, with changes in subject-matter pedagogy occurring as a result of changes in knowledge of subject matter itself. Teacher educators have to be the models of effective practice to initiate the knowledge transformation process in pre-service teachers. Teacher education should have the space for reflective practice in order to make this transformation possible. Blömeke et al. (2014) observed a causal relationship between pre-service teachers' PCK and their beliefs about teaching and learning. This points to the notion that PCK formation can be influenced by many other informal factors within teacher education.

Teacher education has to prepare novice teachers for teaching, which is a complex and uncertain enterprise. They should be ready to continually adjust their instructional strategies and representations to ensure student learning and effectively meet student needs. Clearly, no simple set of instructions exists to inform and prepare prospective teachers for the challenges of planning and teaching (Barnett & Hodson, 2001). Teacher education programmes need to focus on subject matter knowledge. It was observed that stronger subject matter education not only resulted in greater learning gains in terms of subject matter knowledge but also in terms of PCK. A clear notion of the understanding of the construct PCK among the student teachers during teacher preparation will help them excel in their careers as teachers. As the teacher community becomes more professional and effective, it will definitely mirror society also. The use of PCK as a tool for teacher transformation can also build up a better learning community and strengthen scientific temper. Thus, the teacher empowerment focusing on PCK will help in catering for the needs of the milieu.

Good physics teaching at the high school level is hampered by a severe shortage of well-prepared teachers. This shortage is more pressing in physics than in any other field and constitutes the primary challenge in providing a high-quality physics education to all students. During their teacher preparation, physics teachers fail to develop a deep understanding of the subject. They devote much of their time to generic education courses that have limited value to practising physics teachers.

Physics education research conducted worldwide (McDermott & Redish, 1999) indicates that teachers gain much more value from courses and workshops that expose them to physics-specific pedagogy and intensive study of physics concepts in the context of learning to teach physics and from actually teaching it, with expert mentoring. Such experiences can incorporate recent research in physics education that has yielded valuable knowledge of effective curricula, instructional methods, and assessment techniques. These potentially high-value courses and teaching experiences are usually not available at colleges of teacher education, and in all manner, predominantly, they are overshadowed by non-subject specific pedagogical studies. This serious imbalance negatively affects the quality and effectiveness of novice physics teachers. The fact that most new physics teachers have no exposure to modern knowledge of effective physics pedagogy is a terrible waste of resources and represents a gross inefficiency. Teachers end up in a high school physics classroom through a wide variety of routes. Student teachers who have a physics background obtain only very limited pedagogical preparation during teacher education programmes or post-graduate programmes with no focus on discipline-specific pedagogy.

Science, technology, engineering and mathematics (STEM) professionals are having a great role in the coming years and physics is universally recognized as a fundamental and essential STEM discipline. As twenty-first-century science tackles multidisciplinary problems, school systems should teach science in the interdisciplinary manner in which actual science is conducted. Therefore, to prepare individuals who are able to tackle 21st-century multidisciplinary problems, teachers need to have a deep understanding both of content within a specific discipline and of the teaching of that discipline. The central and state government should make sure all classrooms have well qualified and effective physics teachers. The preparation of qualified physics teachers has failed to keep pace with the rise in the number of high-school students learning physics. Consequently, students are taking physics from teachers who are inadequately prepared or have limited experience in physics teaching.

The major objective of this study is to find out the institutional and learner related factors predicting PCK of prospective physics teachers. Developing PCK must be an ongoing process that begins in teacher education and continues with teaching practice and ongoing learning. Hence, identifying the contributing factors of PCK in teacher education programmes will help in providing appropriate and coherent learning opportunities to educate preservice teachers on how to teach effectively.

Statement of the Problem

The study is entitled FACTORS AFFECTING PEDAGOGICAL CONTENT KNOWLEDGE IN PHYSICS AMONG PROSPECTIVE TEACHERS AT SECONDARY LEVEL IN KERALA.

The study identifies the institutional and learner related factors that influence Pedagogical Content Knowledge in Physics among prospective teachers at the secondary level in Kerala. Further, the study tries to identify the possible predictors from the selected factors which contribute to the development of PCK.

Definition of Key Terms

Factors

According to the Oxford English Dictionary (2002), the factor is 'an element which enters into the composition of something; a circumstance, fact, or influence which contributes to a result. In this study, factors denote select institutional and learner related factors that affect the Pedagogical Content Knowledge in Physics of prospective secondary school teachers. The institutional factors are viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator and Teacher Motivation. The learner related factors comprise Attitude towards Science and Self-efficacy.

Pedagogical Content Knowledge

Pedagogical Content Knowledge (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” (Shulman,1987).

Pedagogical Content Knowledge is a measure of the extent to which the teachers can present the content to be taught to the learners using the most powerful analogies, illustrations, examples, explanations and demonstrations depending on the nature of the content. For the present study, Pedagogical Content Knowledge in Physics is the score obtained by prospective teachers in the Pedagogical Content Knowledge Test in the area of mechanics comprising three sections viz., Content Knowledge, Pedagogical Knowledge and Contextual Knowledge.

Prospective Teachers at Secondary Level

In this study, Prospective teachers at the secondary level are the student teachers who study B.Ed Physical Science which makes them eligible to become Physical Science (Physics and Chemistry) teachers who can teach at the secondary level (classes 8 to 12) in schools.

Variables of the Study

This study has one dependent variable, nine independent variables and two classificatory variables.

Dependent Variable

The dependent variable in this study is Pedagogical Content Knowledge (PCK) in Physics. This is a knowledge base for teaching, exclusively meant for physics teachers, which differs them from physicists. PCK in Physics has three facets or components viz., Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK). CK includes knowledge and skills used in settings other than teaching. PK constitutes knowledge about learners and learning, and classroom management. CxK includes knowledge and skills unique to teaching Physics in a unique context.

Independent Variables

Independent variables for this study are a set of select institutional and learner related factors affecting PCK in Physics, viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Teacher Motivation, Attitude towards Science and Self-efficacy which are hypothesized to be related to PCK in Physics of prospective teachers.

Institutional factors

Pre-Internship Learner Engagement

Pre-Internship Learner Engagement includes all possible actions that a student-teacher may do in the classroom as a part of the teacher education programme prior to school internship. This includes engagement of student teachers in activities during teacher education programmes that are aimed at facilitating preparation for teaching, fostering teaching, and transforming teaching.

The variable is regarding how frequently the student-teacher engages himself or herself in the works that are part of the teacher education curriculum, viz., asking doubts and questions during class, observing and following demonstration classes, participation in group works, engaging in peer teaching, taking classes and doing presentations to the whole class etc.

Opportunity to Achieve Learning Objectives

Opportunity to achieve Learning Objectives refers to how frequently the student-teacher, during the teacher education programme, got opportunities to be involved in activities in order to attain learning objectives related to the B.Ed curriculum. All formal, non-formal and informal learning opportunities that the prospective teachers get under the auspices of their teacher education institution to achieve general learning objectives related to the B.Ed curriculum are included under this variable.

Opportunity to Learn Skills

Opportunity to Learn Skills refers to the opportunities that prospective teachers get during the teacher education programme to acquire general and specific teaching skills that are required by every teacher to handle a diverse and inclusive classroom. This includes the opportunity to learn about handling exceptional children, engage with expert and experienced teachers, and understand existing school practices, standards and values.

Engagement during School Internship

It is the extent up to which the prospective physics teachers could complete all the mandatory tasks as part of their school internship. These include how often they could conduct constructivist lessons, practice effective lesson planning, and reflect on lessons for improvement and other engagements.

Accomplishments during School Internship

It is the extent to which the prospective teachers successfully perform various tasks during the school internship. It is a measure to know to what extent they can meet the expectation of their mentors, successfully implement methods and strategies, receive adequate feedback from mentors etc.

Role of Teacher Educator

It is the student perception of the role or competence of teacher educators in facilitating their learning during teacher education programmes at their institution. It includes teacher educator's skills of teaching, communication with student teachers, reach on recent trends in science education etc.

Teacher Motivation

It is the student perception of motivation that they obtained from teacher educators during the teacher education programme. This includes fairness in consideration, personal care and support towards need fulfilment that the student-teacher received from teachers.

Learner related Factors

Attitude towards Science

It is the prospective teacher's attitude towards science teaching-learning. The attitude of student teachers towards science learning, the process of science, interest in science and engagement with science teaching and learning are considered under attitude towards science.

Self-Efficacy

Self-efficacy means the belief of prospective physics teachers in their ability to organize and perform or execute their actions as a teacher. Ability in instructional planning, transaction ability, transaction ability, classroom management and professional approach are considered under self-efficacy of student teachers. The ability to design suitable learning activities for all topics to attain learning goals integrate ICT appropriately in Physics lessons, use assessment and evaluation techniques for giving feedback are considered

Classificatory Variables

Gender and Level of physics studied (the level up to which the prospective teacher has studied physics as a discipline) are the two classificatory variables in this study.

Objectives

1. To find out the extent of Pedagogical Content Knowledge (PCK) in Physics among prospective secondary school teachers and their sub-groups based on
    a. Gender, and
    b. Level of Physics studied.
2. To find out the extent of the relationship between each of the institutional and learner related variables and PCK in Physics among prospective secondary school teachers and their sub-groups based on
    a. Gender, and
    b. Level of Physics studied
3. To identify the significant institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and sub-groups based on
    a. Gender, and
    b. Level of Physics studied

4. To develop a regression equation for predicting PCK in Physics among prospective secondary school teachers and their sub-groups with the select institutional and learner related variables.

5. To find out the relative efficiency of the select institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and their relevant sub-groups.

Hypotheses

1. There will be a significant relationship between each of the select variables and PCK in Physics for the total group and sub-groups based on

    a. Gender, and

    b. Level of Physics studied

2. PCK in Physics among prospective secondary school teachers can be significantly predicted from the select set of institutional and learner related variables.

Methodology

Sample

The study is conducted on a sample of 700 prospective secondary school teachers in Kerala studying in teacher education institutions affiliated with the University of Calicut, Mahatma Gandhi University, Kerala University and Kannur University.

Tools

The tools used for the study are

1. Pedagogical Content Knowledge Test (Ravishanker & Mumthas, 2017)
2. Curricular Experiences Rating Scale (Ravishanker & Mumthas, 2017)
3. Scale on Motivational factors in Science Teaching (Ravishanker & Mumthas, 2017)

Statistical Techniques Used

After the preliminary statistical analysis, the following techniques are used

1. Pearson's product-moment coefficient of correlation
2. Test of significance of difference between correlations
3. Multiple regression analysis

Scope, Delimitations and Limitations of the Study

The main purpose of the study is to identify the factors affecting Pedagogical Content Knowledge (PCK) in physics of prospective secondary school teachers. The study also tries to find out the extent of Pedagogical Content Knowledge in physics among prospective secondary school teachers along with the extent in its components viz., Content Knowledge, Pedagogical Knowledge and Contextual Knowledge. The relationship of select institutional and learner related factors viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Teacher Motivation Attitude towards Science and Self-Efficacy with PCK in Physics are also carried out. The study focuses on whether PCK in Physics of prospective secondary school teachers differs on the basis of their gender and level of physics studied.

The study identifies which among the select institutional and learner related factors are adequate to significantly predict the PCK in Physics of prospective secondary school teachers. The study leads to the derivation of multiple regression equations using which PCK in Physics among prospective secondary school teachers can be predicted from a set of institutional and learner related variables. The study also determines the relative efficiency of select variables in predicting PCK in Physics.

For the purpose of the study three tools are developed viz., Pedagogical Content Knowledge Test, Scale on Quality of Curricular Experiences and Scale on Motivational Factors in Science Teaching. The first tool is a paper-pencil test for measuring Pedagogical Content Knowledge in Physics. The Pedagogical Content Knowledge Test in Physics in the area of mechanics among prospective secondary school teachers was constructed based on three components of PCK. The Scale on Quality of Curricular Experience is a comprehensive tool to assess the curricular experiences that the student-teacher gets through the teacher education programme. Scale on Motivational Factors in Science Teaching is to learn about the student teacher's attitude towards science and their self-efficacy as a novice teacher.

The study paves light into how much today's teacher education programme contributes towards PCK among prospective secondary school teachers and what are the institutional and learner related factors mainly contribute towards enhancing PCK among pre-service teachers. The study can be a handful in reforming teacher education programmes in order to cultivate the idea of need and strengthening of Pedagogical Content Knowledge among the prospective teachers right from teacher education institutions.

The delimitation of this research is that to study PCK in Physics among prospective teachers, the researcher has sampled and gathered data from only some of the teacher education institutions in Kerala. Being the vast and relevant content area in secondary school physics, only ‘Mechanics’ is chosen by the researcher to prepare the test to collect data related to PCK. Only nine institutional and learner related factors are selected as independent variables for the study. The researcher also limited to include only two classificatory variables viz., Gender and Level of Physics studied for the purpose of this research.

Though the investigator tried the best to render objectivity to the study, it is not free from limitations. Some of the limitations are

1. No data was collected from school students whom the prospective teachers taught during their school internship, for cross-checking the PCK of prospective teachers.

2. Even though gender was taken as a classificatory variable male-female ratio could not be maintained in parity due to the nature of gender distribution of prospective teachers in the population.

3. While selecting factors influencing PCK, more importance is given to the institutional related factors than the learner related variables .

Organization of the Report

The report is presented in six chapters.

Chapter 1:

This chapter contains a brief introduction to the problem, need and significance of the study, statement of the problem, definition of key terms, objectives and hypotheses, methodology, scope, delimitations and limitations of the study.

Chapter 2:

This chapter presents the conceptual overview of pedagogical content knowledge and review of the related studies.

Chapter 3:

This chapter describes the methodology of the study which consisted Method, Design, Variables, Instruments, Sample, Data collection procedure and Statistical techniques used for the study.

Chapter 4:

This chapter describes statistical analysis and interpretation, discussion of results and tenability of hypotheses.

Chapter 5 & 6:

These chapter deals with the summary of the study, major findings, implications of the study and recommendations for further research.

REVIEW OF RELATED LITERATURE

Review of related literature is an essential aspect of any investigation. The investigator must make a thorough survey of related studies before planning and carrying out the study. A proper study of related studies would enable the researcher to locate and go deep into the problem (Best & Kahn, 2006). A review of related literature is done to get an insight into the theoretical background of the subject of study.

The result of the review is summarised in this chapter. For convenience, this has been attempted under the following heads.

Conceptual Overview of Pedagogical Content Knowledge

Studies related to Pedagogical Content Knowledge

Conceptual Overview of Pedagogical Content Knowledge

This chapter aims to review methodologies and techniques used to assess teachers' pedagogical content knowledge or its related components. Mainly focusing on studies of pedagogical content knowledge related to science teaching; however, we also refer to studies from other disciplines that might help consider how pedagogical content knowledge can inform teaching in science. The conceptual overview of the variable Pedagogical Content Knowledge (PCK) is presented under the following heads.

A. Conceptual framework for the knowledge base of teaching

B. Pedagogical Content Knowledge (PCK)

C. Teacher Education

A. Conceptual Framework for the Knowledge Base of Teaching

The researcher examined various concepts of teacher knowledge and their impact on teacher training programmes around the world. The National Curriculum Framework (NCF) 2005 highlights the need to renew the teacher training programme, noting that the current teacher training programme is insufficient to create better-equipped and thoughtful professionals in the education sector. According to NCF 2005, teachers lack the expertise to develop links between school and society and are reluctant to conduct educational experiences. The capacity of teacher training programmes reflects in the following lines of the document.

"Most teacher education programmes provide little scope for student-teachers to reflect on their experiences and thus fail to empower teachers as agents of change." (NCF, 2005)

Given the arguments put forward in national documents like NPE (1986), NCF (2005) and NEP (2020), it is necessary to renew the teacher training programme, for which the pedagogical content knowledge (PCK) offers a glimmer of hope. In the West, however, PCK construction has contributed to too much research in teacher training. The literature reviewed helped in conceptualising PCK's emancipatory role in teacher education.

Teacher Knowledge: Two Parallel Concepts. A conceptual framework for the knowledge base of teaching enables us to say what we are teaching and assessing and what we are not (Reynolds, 1992). Shulman (1987) first aroused the interest of others with the idea of a knowledge base for teaching. When Shulman introduced this idea in response to defining the professional knowledge base for teachers, the knowledge base for teaching was also used to describe the knowledge base of teaching. These two concepts, which are parallel and related, are explained below.

Knowledge Base for Teaching (Profession)

The American Association of Colleges for Teachers Education (AACTE) perhaps presented the first formal view of a knowledge base for teaching, referring to it as "The Knowledge Base for Beginning Teachers" (Reynolds, 1989). Later on, new knowledge frameworks for teachers came in, "knowledge base for teaching". Knowledge base for teaching has become a common phrase in the teacher preparation programmes (Reynolds, 1992), encompassing the various types of teacher knowledge required for teachers to teach. Shulman's (1987) view of the knowledge base for teaching comprises seven knowledge categories: content knowledge, learners and learning, curricular knowledge, knowledge of contexts, general pedagogical knowledge, knowledge of goals, and pedagogical content knowledge.

Shulman's (1987) formulation of the knowledge base for teaching has been criticised as simple because it provides an objectivist view of the teacher's knowledge and omits the complexity of teaching (Barnett & Hodson, 2001; Carlsen, 1999; Sockett, 1987; Valli & Tom, 1988). Despite criticism, Shulman's point of view encouraged a review of teacher education and opened a debate in teacher education communities about teacher knowledge and thinking. Abell (2008) argued that Shulman's knowledge base was different from earlier conceptualisations introduced in the 1960s and 1970s, which contained only a set of rules for effective teaching. Abell pointed out that Shulman's understanding of teachers' knowledge was generally different because it came from working with real teachers and their knowledge of particular subjects. The idea of a knowledge base for teaching helps to design teacher training based on existing framework conditions.

For this reason, it is a dynamic concept that constant evaluation is needed to respond to the latest developments in this area. Strom (1991) indicated the need to redefine the knowledge base for teaching for four reasons: (a) determining the content and structure of teacher training, (b) assessing the quality of teacher training programmes, (c) evaluating teacher and teaching and (d) teacher assessment for professional certification. In addition, while recognising teaching as a profession, the teacher's knowledge must be taken into account by (a) the type of knowledge required and the relationships between the identified knowledge categories, (b) the conceptual framework for the organisation and use of knowledge and (c) the research methods used to create and validate knowledge claims in this area (Strom, 1991). Darling-Hammond (2006) suggested that teacher training should focus on the "close link between theory and practice, course work and clinical work" to build a professional knowledge base for teaching. Hiebert, Gallimore and Stigler (2002) have proposed a new term that encompasses the idea of a knowledge base for teaching, namely "knowledge base for the teaching profession", which clarifies the underlying meaning.

The Knowledge Base of Teaching (Personal)

Hiebert et al. (2002) found that each teacher has a "personal knowledge base" of teaching that defines their practice, and this knowledge base differs from the knowledge base for teaching (that is, the professional). This personal knowledge base guides and influences a teacher's actions in explicit pedagogical situations (Brown &McIntyre, 1993). A teacher's knowledge is also the knowledge base of teaching, as it emerges from actual teaching, unlike the term knowledge base for teaching, which commonly defines the knowledge required for teaching.

A teacher's knowledge base is also described in terms such as practical knowledge (Elbaz, 1981, 1983), personal knowledge (Lampert, 1985), experiential knowledge (Clandinin, 1985, 1988) and practical knowledge (Clandinin & Connelly, 1995, 1996). The personal knowledge base is transient, subject to change, and situated in personal experiences inside and outside the classroom (Barnett &Hodson, 2001). We can call "teacher knowledge" the personal knowledge base of education. Verloop, Van Driel and Meijer (2001) argued that teachers' knowledge and formal propositional knowledge should be included in this knowledge base (for the teaching profession).

In summary, the knowledge base for teaching is a broader perspective that encompasses various aspects of the knowledge needed for teaching in general, while the knowledge base of teaching is the knowledge that individual teachers have and use for teaching. It is helpful to differentiate this knowledge base for teaching (professional or academic knowledge) from the personal knowledge base of a teacher (Verloop et al., 2001).

Developing terminologies and approaches to studying teacher knowledge and the ideas about teacher knowledge have changed over time, as have approaches to teaching-learning. Many terminologies were developed to describe different knowledge of teachers. The following section provides an overview of teacher knowledge and introduces new terminologies that represent this knowledge.

Teacher Knowledge as a Referent of Student Achievement

In the 1960s and 1970s, research on processes and products dominated studies on teaching, and the terms associated with at that time were "teacher behaviour" and "teacher characteristics". Efforts were made at this time to combine classroom factors and student achievement. In a meta-analysis of teacher effectiveness in recent decades, Siedal and Shavelson (2007) found that "early research on teaching effectiveness assumed that certain teaching actions and conditions would have an impact on student achievement". They argued that the product-process approach took into account variables related to "product (student), process (teaching), presage (traits) and context". Product variables in consideration here were student's achievement and their attitudes toward learning. The process variables considered were mainly the characteristics of the teachers, i.e., their personality traits and behaviour in the classroom, which potentially influenced students' achievement and attitudes towards learning. The predictors considered were student characteristics such as age, gender, socioeconomic status, skills, and contextual variables were parental involvement, technology, and media.

The predominant approaches in product-process research are large-scale surveys, correlation models or quasi-experimental designs to control external variables and examine the impact of these variables on student performance (Siedel & Shavelson, 2007). Neither schools nor teachers have a significant impact on student performance, which is why "academics and policymakers concerned about justice and improvement of education saw little need for research on teaching or improving the quality of the teaching profession"(Porter & Brophy, 1988). Hence, terms representing teachers' knowledge in those times viz., teacher traits, teacher personality traits, and teacher behaviour were inappropriate.

Teacher Knowledge as a Referent of Student Learning

In the late 1970s and early 1980s, research expanded to explore different teaching strategies and their effects on students' cognitive development. Expansion led to a view of teaching that incorporated student learning, in contrast to the previous view of student achievement as an outcome of effective teaching (Darling-Hammond, 2000). From a cognitive perspective, the teachers were intermediaries and responsible for creating an effective learning environment, taking into account cognitive and metacognitive activities (Brophy & Good, 1986), leading to the student's cognitive development. Educational research in those times associated with teaching focused on the learning theories and the learning environment that help students learn and the ability of teachers to facilitate and create constructivist learning environments. The predominant approaches in research on student learning and constructivist classes included positivist research using surveys, correlation models or quasi-experimental designs, as well as qualitative research using interviews or case studies on the role of the teacher, the thinking of the students and the impact of various teaching strategies on the thinking of the students.

Teacher Knowledge as a Referent of Teacher Cognition and Practice

Research into teacher cognition and knowledge development flourished in the 1980s (Clark, 1988). As part of this, Elbaz (1981, 1983) suggested that teachers develop their knowledge through the act of teaching - something they called "practical knowledge" - and had proposed five dimensions of knowledge: (i) Subject matter, (ii) instruction, (iii) curriculum, (iv) self and (v) teaching milieu (environment). Elbaz used a case study approach for this research and then proceeded with a narrative inquiry to examine the teaching and practical knowledge of the teachers. Lampert (1985) suggested that teachers develop "personal theories" to solve educational problems and called these theories "personal knowledge". She used a self-study approach to research her classroom, study her practice, and develop stories of that practice.

According to Clandinin (1986), the knowledge of teachers is "experiential, value-laden and practice-oriented", which they called "experiential knowledge". Connelly and Clandinin (1986) used a longitudinal study to examine what knowledge teachers have and how they use it. They called this knowledge "personal practical knowledge". They claimed that this knowledge is subject to change based on personal experiences inside and outside the classroom. Other terminologies used to describe teachers' knowledge are the wisdom of practice (Schwab, 1971), professional knowledge (Tom &Valli, 1999) and professional craft knowledge (Brown & McIntyre, 1986). In addition, Shulman (1986, 1987) introduced the term "Pedagogical Content Knowledge" (PCK). He initiated and contributed to the debate on teachers' knowledge by presenting a new vision of the study of teaching centered on the subject taught. He presented his views on the knowledge base for teaching and the seven categories in this knowledge base. Pedagogical Content Knowledge (PCK) is considered the most critical category that differentiates a teacher from a content specialist (Shulman, 1987).

The term "professional knowledge" is used to describe knowledge in all occupations. According to Dickenson (2007), it is "dynamic, intellectual, personal, focused on the development and research-informed, achieved in synthesis". In the context of the teaching profession, Cochran-Smith and Lytle (1999) introduced three terms: knowledge for [teaching] practice, knowledge of [teaching] practice and knowledge in [teaching] practice. These terms clarified the meaning of teacher knowledge and established links between teacher knowledge and practice. The term "knowledge in practice" is similar to the term "knowledge in action" introduced by Clandinin and Connelly (1986), which is the knowledge that is studied, used or applied in practice and for them, knowledge in practice is epistemologically the only teacher knowledge because it provides evidence that the knower and the known are one. Knowledge of Practice is the knowledge that teachers have about their teaching experience, and knowledge for practice is the knowledge needed for teachers to teach. Researchers have used various terms to describe teacher knowledge, but they all agree that teachers have theories that can contribute to the professional knowledge base of teaching (Zeichner, 1994). These teacher theories, which have evolved due to continued engagement with the curriculum, students and specific environments (classroom, school, etc.), are of immense value.

Teacher knowledge: A Dualism

In addition to new ideas about teachers' knowledge, the "knower and known" nature was discussed (Fenstermacher, 1994). In his in-depth review of the literature on teaching, Fenstermacher noted various concepts of teacher knowledge aimed at "reconsidering the epistemological nature of what can be known by and about teachers". He classified the research literature on teacher knowledge into two study areas: (a) the knowledge that teachers generate based as a result of their experience of classroom teaching - in other words, practical knowledge, and (b) knowledge about teaching that is generated by those who specialise in research on teaching which is formal knowledge and that can be generalised across various contexts. Fenstermacher (1994) also found that practical and formal knowledge differed epistemologically. He proposed that practical knowledge is developed by reflecting on action and experience and is "related to how to do things, the right place and time to do them, or how to see and interpret events related to one's action". In addition, Fenstermacher suggested that formal knowledge develops through research on teaching using various methods and is a "modification of what is known as standards, or justified true belief or account of human knowledge".

Cochran-Smith and Lytle (1998) also supported the deconstruction of the dualism of practical-formal knowledge by merging their two categories: knowledge for teaching and knowledge about teaching. Using new terms to represent teachers' knowledge can resolve the dichotomy between practical and formal knowledge, for example, theories in practice (Edelsky et al., 1991), practical theories (Sanders & McCutcheon, 1986) and practice (Lather, 1986).

Teacher Knowledge: Informing Teacher Education

The primary source of professional knowledge for teachers that influences teacher education is research on teaching to expose teachers' knowledge (Tom & Valli, 1999). One of the goals of research into teacher knowledge is to study the teachers' theories to inform the knowledge base for teaching (teacher preparation), but the validity of this knowledge base is in question, especially for teacher educators. The two challenges are: (a) the epistemological traditions for the production of professional knowledge (research on teaching) and (b) the relationship between knowledge and practice. As Tom and Valli (1999) found, "the epistemological orientations of educational knowledge help clarify the knowledge-practice relationship".

Cochran-Smith and Lytle (1998) defended the value of practical knowledge, which he called local knowledge, to inform formal knowledge (public knowledge). He also suggested the use of local knowledge for public knowledge. Nevertheless, "only a few interpreters take the time to question the usefulness of the results of the sciences of interpretation for teaching" and for teacher training (Tom & Valli, 1999).

National Council for Teacher Education (NCTE) recommends urgent and comprehensive reform in teacher education through professional research and continuing professional development of teachers at all stages of schooling in terms of level, duration and structure (NCFTE, 2009). The researcher's responsibility is to think of innovative ways to deconstruct epistemological dualism by converting local knowledge (personal theories) from teachers into public knowledge (formal knowledge) of teaching to reform teacher education programmes.

The review on teacher knowledge identifies the problem of dualism in teacher knowledge, a growing gap between knowledge of teaching and knowledge for teaching. So, it is necessary to consider the factors in teacher preparation programmes that we believe to be important in moulding the knowledge of teaching a specific topic and developing teacher education programmes supporting the development of topic-specific Pedagogical Content Knowledge (PCK). All types of teacher knowledge described in the research literature are essential aspects that teachers develop through practice and experience (Clandinin 1986; Connelly & Clandinin, 1986; Elbaz, 1981, 1983). Teaching pedagogical content knowledge is considered essential (Fenstermacher, 1994; Shulman, 1987) because it focuses on "teaching specific content" included in the school curriculum. The following sections provide an overview of the relevant literature related to Pedagogical Content Knowledge (PCK) to place this construct in a broad view of the teacher's knowledge.

B. Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge (PCK) is the specialist knowledge teachers require to teach specific content, a teacher's primary responsibility. According to Shulman (1987), PCK includes the most useful forms of presenting the content to be taught, the most powerful analogies, examples, illustrations, explanations and demonstrations. That means representing and formulating the content to make it comprehensible to others.

Pedagogical content knowledge has evolved since Shulman introduced the idea in 1986 in his project Learning to Teach, which emphasised on understanding and learning the epistemology of development of teachers' knowledge. Shulman

(1986) presented PCK as the expertise that distinguishes the true teacher from a content specialist and thus captures the knowledge necessary for effective teaching. He also asserted that the teacher's teaching knowledge was focused on particular topics; thus, PCK is called topic-specific knowledge.

When Shulman first introduced PCK in 1986, he only referred to knowledge of student understanding and teaching strategies (which he originally referred to as representations) as fundamental components of PCK. In his Learning to Teach project, he viewed the PCK as a subcategory of content knowledge, but shortly afterwards, in his 1987 article "Knowledge and Teaching: The Basis of the New Reform", Shulman (1987) redefined PCK as a separate category of teacher knowledge. He viewed the PCK as "an independent knowledge base for teaching that is a mixture of content and pedagogy to understand how certain topics and problems are organised, presented and modified according to different population of learners and presented for instruction".

Further research and discussion on PCK examined the categories of teacher knowledge that shape the PCK of teachers in different areas of the curriculum, leading to other categories of components related to teacher knowledge being included in the definition of PCK (Grossman, 1989; Loughran et al., 2001; Magnusson et al., 1999; Tamir, 1988). However, some research on the PCK continues to use Shulman's original vision and definition of the PCK as a type of content knowledge. Many researchers have been critical about the design and structure of PCK, and their contributions have introduced various extensions to the construction of PCK.

A study by Grossman (1989) on understanding PCK development for English teachers provides an expanded model that describes the development of PCK. She has included in PCK:

(a) Knowledge of goals

(b) Knowledge of students' understanding

(c) Knowledge of instructional strategies

(d) Curricular knowledge

Grossman also attempted to develop links between the PCK and other types of teacher knowledge viz., subject knowledge, general pedagogical knowledge, and contextual knowledge. Grossman developed this model by examining the PCK literature and thus organising the PCK of the participating English teachers.

Similarly, Marks' (1990) study on PCK of mathematics teachers led to another PCK model that included new categories of teacher knowledge according to him PCK consists of four categories of knowledge: (a) content knowledge, (b) knowledge about the understanding of students, (c) instructional media related to subject area, and (d) educational processes for the subject. He recognised the need to clarify the structure of the PCK and emphasised on developing a clear and complete picture of the PCK in various disciplines.

Cochran et al. (1993) tried to look at teachers' knowledge in the based-on constructivism. They proposed a new construct, pedagogical content knowing (PCKg), and presented a model to represent it. As per their model, PCK is integration of four types of knowledge: (a) knowledge of the subject, (b) knowledge of pedagogy,

(c) knowledge of the students and (d) knowledge of the contexts. As the studies related to PCK expanded or developed, all four of these knowledge aspects also transformed.

After nearly three decades, the term Pedagogical Content Knowledge (PCK) introduced by Shulman (1986, 1987) has not yet reached a clear and unified definition even after extensive research into science teacher knowledge among researchers (Abell, 2007; Berry, Loughran & Van Driel, 2008). The Pedagogical Content Knowledge (PCK) construct has been used inconsistently, and many of its features were overlooked by researchers (Abell, 2007, 2008). Pedagogical Content Knowledge is very attractive because of its potential utility in teacher education programmes, and PCK research has largely overlooked the its careful clarification. Consequently, “the construct (PCK) did not impact the valuing of science teachers’ professional knowledge and practise positively, which is a big deal for such an important profession”.

Any research on Pedagogical Content Knowledge conducted without a deep understanding of the PCK construct can lead to different interpretations that can lead to limited or misleading effects. Therefore, it is crucial to understand PCK as a whole in order to evaluate it. In addition, a deep understanding of researchers about the PCK as a whole can help researchers accurately interpret their research.

The construct PCK lacks clarity both philosophy wise and structure-wise. The literature shows an ongoing debate about structural clarification, which mainly relates to the knowledge components contained in PCK and relationships. The nature of pedagogical content knowledge itself is not explicit.

Many teachers find it difficult to express their personal and practical knowledge. It is generally accepted that teachers' knowledge is tacit, so it is difficult to make it explicit. Loughran et al. (2006) argue that PCK is implicit knowledge and that science teachers cannot articulate it. Against this view, Kennedy (1998) argued that PCK "must be explicit and not tacit" He used the example of knowing how to get to the grocery store and giving instructions to reach it, which cannot be done without explicit knowledge. Likewise, suppose a teacher has a solid conceptual understanding of a subject and can solve problems and argue abstractly about solutions to problems in a particular area. In that case, that teacher may not help students understand these problems unless his own knowledge is explicit, having explicit knowledge is vital in part because it enables teachers to decide what is essential to teach, what should be taught now rather than late, what kind of problems could be posed to students that would most likely facilitate their understanding of some particular ideas. According to Grossman (1990), the sources of PCK are observations in the classroom as students and during teacher training in the workplace, scientific studies; Teacher training programmes, and personal teaching experience. Following Kennedy (1998), this study assumes that future science (Physics) teachers should articulate their knowledge of teaching a specific science curriculum by developing science PCK. This research focuses primarily on the knowledge of the pedagogic content knowledge (PCK) of future teachers that they have acquired during university courses and the teacher preparation programme.

Nature of Pedagogical Content Knowledge

Pedagogical Content Knowledge is vital to teacher knowledge. However, the nature of PCK is still evolving. “Knowledge” can be viewed as disciplinary, practical and experiential (Deng & Luke, 2008): concepts of disciplinary knowledge describe knowledge from various established disciplines, concepts of practical knowledge represent procedural knowledge derived from the wisdom of practice, and knowledge of experience are designed as in localised human experience and practice.

Practical and Experiential Nature of PCK

The types of teacher knowledge viz., practical knowledge, personal knowledge, personal practical knowledge, professional knowledge, the wisdom of practice, and others are crucial types of knowledge that teachers develop themselves through practice. Elbaz (1981, 1983), Clandinin (1986) and Connelly and Clandinin (1988) have used innovative approaches to study teachers and teaching. Knowledge of the pedagogical content is considered essential for teaching (Shulman, 1987; Fenstermacher, 1994), but “what is difficult to determine in this work is whether it is a clear formal type or practical in type or blend of the two” (Fenstermacher, 1994).

Research on Pedagogical Content Knowledge in science education has reported on the knowledge of experienced and inexperienced science teachers in various topics to assess or evaluate their professional expertise. This line of research has also documented the PCK of experienced science teachers (Loughran et al., 2001, 2002, 2004). These researchers studied experienced science teachers to demonstrate their topic-specific science PCK and demonstrate their knowledge of specific science content. PCK has been studied by working with real teachers, understanding what they know about the subject matter, and understanding how to teach it (Abell, 2008). According to Gudmundsdottir (1991): “Pedagogical content knowledge is mostly “homemade” developed through experience, by working with texts, subject matter and students in different contexts year after year, and in the case of some experienced teachers, for decades. Pedagogical content knowledge is a practical way of knowing. It is learned mostly while teaching by trying things out and observing, talking and working with other teachers”. PCK is the “knowledge possessed by expert teachers” (Veal & Makinster, 1999). Fenstermacher claims that PCK is no different from personal knowledge and personal practical knowledge (practice) (1994,). This argument indicates the experiential and practical nature of PCK. The issue with teacher education programmes is the disconnect between what teachers know based on their practice (practical knowledge) and what student teachers need to know to become competent teachers (formal knowledge).

Narrative and Value-Laden Nature of PCK

Gudmundsdottir (1990) also noted that teacher educators should help prospective teachers to understand the impact of values on the development of pedagogical content knowledge and the impact of their values on their teaching practice. Gudmundsdottir working with Shulman in his project Knowledge Growth in Teaching has written extensively on the narrative character of the PCK. Hashweh (2005), also highlighted the value-laden and narrative nature of PCK. He said: PCK has value or beliefs components and has a subject matter component, a purpose component, a pedagogy component and other components. Teachers develop what some have called an amalgam of subject matter knowledge and pedagogy and other categories to teach particular topics. This idea of educational content related to the teacher's beliefs about content or topics was not unique to Gudmundsdottir. Shulman and colleagues have already emphasised this component. However, Gudmundsdottir's notable contribution was his insistence on the value-laden and narrative nature of PCK.

Hashweh (2005) has represents PCK as a series of topic-specific pedagogical constructions (TPC) that forms fundamental knowledge units or entities. According to him, "a group or collection of these small units of knowledge" is called Pedagogical Content Knowledge. Hashweh suggested that PCK should be considered as collection of TPC than as a whole. A teacher develops TPCs as he teaches the subject over a long period in various contexts, these small knowledge units are very much related to the personal experience and values of the teachers. Barnett and Hodson (2001) emphasised the contextual nature of the construct PCK and argued that PCK could only be developed or understood in a specific context. He also proposed the new term "pedagogical context knowledge (PCxK)." According to Gudmundsdottir (1991), the study of teachers' narratives will help educators to understand pedagogical content knowledge in detail. A teacher's narrative is studied by interpreting his/her teaching experience. The above narrative paves light on the role of teacher preparation programmes and their curricula in shaping the PCK of prospective teachers. PCK in student teachers can be accomplished by providing the student teachers with all possible experiences and learning environments in the institution by which they can construct their pedagogical content knowledge related to concerning subjects.

PCK: Transformation of Formal Knowledge into Practical Knowledge

Although there are very few cases in teacher education where educational research results are implemented, the value of these efforts has been widely discussed. Loughran and Berry (2011) suggested that "paying careful attention to how knowledge is created and used offers interesting opportunities for developing approaches to teacher learning . . . as well as how others interpret and use that knowledge in their practice". Cochran-Smith and Lytle (1998) suggested that pedagogical content knowledge is a term that has the potential to reduce the dualism of practical and formal knowledge. They also suggested using terms such as "theories in practice" and "practical theories". However, it is unclear how this deconstruction process can be accomplished. Using the terms recommended above can also help overcome the dichotomy between consumers and producers in terms of teacher knowledge and support joint efforts to convert practical knowledge into formal knowledge. Cochran-Smith and Lytle (1999) argued that the value of practical knowledge lies in informing formal knowledge. This research seeks the possible dimensions and factors related to teacher preparation programmes that will influence the student teachers' pedagogical content knowledge.

Loughran et al. (2001, 2004, 2006) developed Content Representation (Co-Re), a method for representing the PCK of experienced science teachers, and PaP-eR (Pedagogical and Professional Experience Repertoires) to provide explanations for the thinking of teachers. They are involved in the process of conveying specific content. A Co-Re is a matrix that contains the "big ideas" on the flat side and the associated conceptual understanding of the teacher required to convey these concepts on the vertical side. Likewise, Pap-eRs are teachers' collective stories and stories about their achievements and the problems associated with implementing individual educational strategies for teaching certain academic subjects. Loughran et al. (2004) have developed a framework for documenting the specific PCK on science teachers in the form of these Co-Res and Pap-eR. Loughran et al. (2006), in their book Understanding and Developing the Pedagogical Content Knowledge of Science Teachers, presented units on PCK of experienced science teachers to teach certain science subjects of middle and upper secondary level in the form of Co-Res and Pap-eR. These units are examples of transformed science PCK, a type of professional knowledge or expertise. Loughran et al. recommended using Co-Res and Pap-eR for science teachers in initial training to help them develop their subject-specific scientific PCK. There is evidence of the use of blank Co-Res to develop the PCK of science teachers and instructors of science teachers (Hume and Berry, 2011). However, it is unclear how these previously developed Co-Res could be helpful in prospective science teachers' learning during initial training.

Furthermore, there is no evidence that the use of Pap-eR influences teacher training, but they could undoubtedly be used as case studies to develop PCK for science teachers. The researcher feels that it will be effective if student teachers are given proper training for PCK development as part of their pedagogy course during the teacher education programme. Also needed are other innovative ideas used in teacher preparation programmes to develop topic-specific science PCK.

Summary of literature gives a clear view of contemporary conceptions of teacher knowledge. Pedagogical content knowledge is practical knowledge beneficial for science teachers and is best-considered teachers' professional knowledge. Cochran-Smith and Lytle (1998) suggested that PCK should be transformed to help preservice science teachers learn how to teach science effectively. The research timeline on pedagogical content knowledge and important ways and models related to PCK and its evolution are explained below.

PCK: Conceptualisation in Science Education

Carlsen (1999) proposed the first theoretical conceptualisation of PCK for science teachers, specifically for science teaching. He presented it diagrammatically in an edited book on science education and pedagogical content knowledge, Examining Pedagogical Content Knowledge: the construct and its implications (Gess-Newsome & Lederman, 1999). He used and modified Grossman's PCK model (1989) to design a model that represents the PCK for science education.

Magnusson et al. (1999) carried out a comprehensive analysis of the PCK literature and proposed a new theoretical conceptualisation of PCK for science education. His diagrammatic representation of science PCK offered a comprehensive view of the pedagogical content knowledge of science teachers. According to him, PCK has five components of knowledge that are connected hierarchically : (i) Orientation to science teaching, (ii) Knowledge and beliefs about the science curriculum, (iii) Knowledge and beliefs about students' understanding of specific science topics, (iv) Knowledge and beliefs about instructional strategies for teaching science and (v) Knowledge and beliefs about assessment of science. He also described the relationships between these five aspects of knowledge and provided a more detailed description of each. In the last decade, Park and Oliver (2006) and Lee and

Luft (2008) provided empirical evidence of their ideas on expanding the science teachers' PCK. Park and Oliver (2006) identified five components of PCK knowledge from the literature and developed a pentagonal theoretical model with same as those of Magnusson et al. (1999) but are not organised hierarchically.

In the Park and Oliver (2006) model, PCK is at the center of the pentagon, while the five aspects of knowledge are at the five corners. Their research on three chemistry teachers helped develop their theoretical PCK model. They added a new component, teacher effectiveness. Their pentagon model was hence converted into a hexagonal model with PCK in the middle and six components at the six corners. They also studied new dimensions of PCK by incorporating the roles of teacher qualifications, their particularities and considerations, and reflection in action and reflection on action. Lee and Luft (2008) examined the PCK of four experienced science teachers using a case study approach. They identified seven knowledge components that contribute to the science PCK of science teachers: 1. Knowledge of science 2. Knowledge of goals 3. Knowledge of students 4. Knowledge of curriculum organisation 5. Knowledge of teaching strategies 6. Knowledge of assessment 7. Knowledge of resources. They also identified specific elements in these seven aspects of Knowledge. Their efforts to display science teachers' PCK have resulted in graphical representations of each science teacher's unique PCK.

Gess-Newsome (1999) suggested two parallel models that distinguish the quality of pedagogical content knowledge: (a) an integrative model and (b) a transformative model. The integrative model presents individual teacher knowledge categories coming together as PCK. In an integrative model, teacher knowledge categories exist separately, and the teacher draws upon them to make pedagogical decisions. In contrast to this, in the transformative model, the previously disparate knowledge categories are consolidated to generate a new knowledge category, PCK. This consolidated form of PCK is framed as “transformed” PCK, which is ready to use in new pedagogical situations. So, transformative PCK exists as a distinct knowledge category that is more unified than integrative PCK, which exists as individual knowledge categories and is less unified. Using this distinction to assign quality rankings to the PCK of science teachers, transformative PCK represents high-quality PCK while integrative science PCK represents poor-quality PCK.

Apart from including new knowledge components in PCK, the researchers tried to identify the relationships between these knowledge components in order to make it clear. In their attempt, they found that the “boundaries of PCK are blurry” (Loughran et al., 2000). In 1998, Gess-Newsome and Lederman referred to similar uncertain boundaries, using the ideal gas analogy to state that it is difficult to clearly understand the role of the individual knowledge components within PCK. However, they claimed that studying the individual knowledge components of PCK can contribute towards understanding the development of PCK. This argument made it essential to understand all of the knowledge components of PCK of science teachers to examine how these individual knowledge components are organised in the total PCK of science teachers, which may help understand the construct PCK. An important point here is that Lee and Luft (2008) studied PCK with science teachers who taught topics in different subject areas. This provides a possible explanation for their different representations of PCK in science teachers.

Most of the topic-specific science PCK research has examined selected pieces of knowledge from the science teachers' PCK, which has not contributed much to the understanding and development of the construction of the PCK. Park and Oliver (2006) studied the PCK of chemistry teachers who taught various chemistry subjects to derive a more lucid representation of their PCK, which could represent their domain-specific science PCK. Van Driel et al. (1998) consider that PCK is essentially topic-specific knowledge and have developed a research programme to provide examples of topic-specific science PCK in various curricular topics. His research contributed to the discussion of PCK but did not offer a new model and instead relied on multiple definitions existing in the research literature. Their research studied the topic-specific science PCK of science teachers across various curriculum areas (Loughran et al., 2001, 2004, 2006) and believed that PCK is essentially topic-specific knowledge. However, they contributed to understanding science teachers' topic-specific science PCK and the knowledge base of science teacher education. They have not explained the existing PCK models in more detail, and they preferred to study and document topic-specific science PCK using their unique approach. Hence, they ignored new developments in the understanding of PCK. The reason may be the relevance or sufficiency of existing PCK models for their research goals.

Assessment and Measurement of Pedagogical Content Knowledge

Many researchers and educators have adopted pedagogical content knowledge since its inception by Shulman in 1987. Teacher educators have begun to assess their success in expanding teachers' pedagogical content knowledge (Smith & Neale, 1989, 1991), while researchers from various disciplines have also examined the influence of

PCK on teachers' beliefs, classroom practice and student understanding (Grossman, 1990, Hashweh, 1985, 1987; Lederman & Zeidler, 1987: Peterson, Fennema, Carpenter & Loef, 1989; Wilson & Wineburg. 1988). Teacher educators and researchers consider PCK an essential part of the knowledge required for teaching (Shulman, 1987).

Researchers and teacher educators have developed various methods and techniques for examining PCK, such as paper and pencil tests (especially multiple-choice tests), concept maps, visuals, interviews and multi-method evaluations. These techniques have served teacher appraisal, staff development, and curriculum development.

Kagan (1990) identified several challenges in assessing teacher cognition: many of his concerns relate to assessing pedagogical content knowledge. By definition, PCK is partly an internal construction; it is the teacher's understanding of the content-specific examples that best represent specific topics and the knowledge of the students' common difficulties with particular content areas; studying a teacher's knowledge of the "best examples". We cannot rely solely on observational data, and a teacher may use only a limited portion of their stock of examples during a particular lesson. As observers, we will have no idea which examples the teacher did not use.

Furthermore, observation would not reveal why the teacher used some examples and avoided others. The comments or statements give only a little insight into the PCK: teachers have to articulate their knowledge. It requires a variety of techniques to help teachers communicate their knowledge. These techniques range from open prompts to structured interviews, and each has its strengths and weaknesses.

Grossman and Yerian (1992) identified more than thirty-eight studies of some aspect of pedagogical content knowledge: however, only a tiny portion of those studies focus on teaching the sciences. They categorized the studies into three groups: (a) convergent and inferential techniques. (b) concept mapping, card sorts, pictorial representations, and (c) multi-method evaluations.

Convergent and inferential techniques include Likert-type scales, multiple-choice items, and short answer formats. All of these formats use pre-established verbal descriptions of the knowledge teachers want as a benchmark for comparing the verbal responses of teachers in training and the workplace. Although these formats help measure teachers' attitudes and beliefs, they have not received much attention in any discipline when assessing pedagogical content knowledge.

Kromrey and Renfrow (1991) used multiple-choice test items to measure content-specific pedagogical knowledge (C-P). They consider content-specific pedagogical knowledge separate from content knowledge and general pedagogical knowledge; their construct, C-P, certainly sounds similar to pedagogical content knowledge with a slight variation in the label. Kromrey and Renfrow developed a working definition of items that assessed pedagogical content knowledge and called them “C-P items.” The C-P items include those items for which the examinee’s determination of the correct response depends upon knowledge of content handling in educational situations. C-P items address the process of teaching the content, not the non-instructional practice of the discipline. They further distinguish among four categories of C-P items: error diagnosis, communicating with the learner, organisation of lesson, and learner characteristics.

Error-diagnosis items measure whether the teacher can recognise students' logical errors. Communicating with the learner requires the teacher to identify appropriate communication between teacher and student (e.g. when a student appears confused, what would be the next step" activity or query to help the student understand the problem?). The organisation of lesson items focuses on teachers' plans for teaching (e.g., An unsuccessful activity and a successful corrected activity are described, and the respondent identifies a reason for how the correction worked). Learner characteristic items evaluate teachers' knowledge of developmental standards within the discipline or categorisations of skill development (e.g., a teacher is having some trouble teaching fractions to first graders. Why?). According to Kromrey and Renfrow, the four categories are not comprehensive but mirror the types of items that have been developed so far. Their operational definition and four categories of C-P items are a noble start to an arduous task (assessing pedagogical content knowledge) and helped solve the problem space, the intersection of knowledge about content and pedagogy.

Kromrey and Renfrow (1991) mention a significant concern related to psychometrics. Even though they produced promising initial results regarding the item's difficulty and reliability, they suggest the need to examine other psychometric properties. It is required to examine the construct validity of every C-P item. Are these carefully created and reliable items not measuring what we intend to measure, namely pedagogical content knowledge. They note second anxiety: C-P items are more challenging to write, edit and analyse than content or general pedagogy items. Given the content-specific and context-specific nature of pedagogical content knowledge, C-P items must describe an instructional event in some detail. The item must include information related to students, the specific topic and the instructional setting. The distractors for C-P items must be dexterously crafted so they are reasonable, in no way defensible. Besides, enough detail must be provided in each choice so that content-specific knowledge is essential to identify the correct answer.

The convergent and inferential methods for assessing pedagogical content are not used widely. Kromrey and Renfrow (1991) developed multiple-choice items that stand out from content knowledge and general pedagogical knowledge, but they have not established what these items measure. Kagan's (1990) concept of ecological validity is helpful in this context. It defines ecological validity as: “The types of evidence provided by researchers regarding the suitability of a measurement technique for everyday classroom use. Are teachers' performance on a particular tool or task related to their teaching behaviour or the outcomes valued by students? "

The assumption regarding Kromrey and Renfrow’s multiple choice exams is that there is a set of correct answers; the sample items they offer are well designed and have a clear, correct answer. Kromrey and Renfrow’s multiple-choice items are certainly simple means of improving current teacher tests: however, it is unclear whether their tests are tapping new knowledge domains. According to Kagan (1990), any researcher who uses a short-answer test of teacher belief (an instrument composed of prefabricated statements) risks obtaining bogus data because standardised statements may mask or misrepresent a particular teacher’s highly personalised ideas and definitions. To make short-answer tests of teacher belief reliable, the researcher can resort to studies of test wiseness, fraudulence, and the effects of language.

Card sorting assignments have been used extensively by Shulman and his students as part of the Education Knowledge Development Program. In a card sorting task, the researcher provides a set of "cards", each card containing a particular concept, idea, and principle. The teacher has to place cards in an arrangement that best illustrates the relationship between the "elements" contained on the cards. This approach is similar to concept mapping as the researcher provides the topics and more flexibility in terms of the final format. However, concept maps and card sorting tasks are too restrictive. Each approach requires either a specific format (hierarchical, static and two-dimensional) or the use of one particular design to represent one's conceptual schema. Therefore, the researcher only gets how the research subject sees the ideas presented by the researcher or a representation restricted to a particular hierarchical format.

Morine-Dershimer (1989) used concept maps to investigate changes in the knowledge structures of prospective teachers at the beginning and the end of a methods course. Students draw two concept maps: one shows the concept they taught in their peer teaching lesson during class, and the second illustrates the concept of "teacher planning". The students provided their key terms and were free to use the graphic design of their choice. The area and density of maps can help understand how future teachers or new teachers develop their knowledge base for the classroom and provide feedback on their understanding.

Cess-Newsome and Lederman (1993) used an open-ended approach to assess the content and stability of 10 preservice biology teachers' knowledge of biology, asking them to answer the following questions: 1. What topics make up your main teaching content area'? If you decide to use these topics to represent the content area graphically, what would it look like? 2. Have you ever assumed about your content area in the way you have been asked to do so above? Individuals were given the freedom to select whatever concepts or ideas best represented their subject matter area and provided the freedom to represent the association between these ideas in any manner that best represented their interpretations. Gess Newsome and Lederman believed their approach (i.e., pictorial representations) provided a more valid representation of preservice teachers' views on the subject matter.

Kagan (1990) notes that a significant flaw in using concept mapping and sorting of cards as a research tool to examine the knowledge and beliefs of teachers is that researchers typically only use them in short-term studies: researchers have not yet investigated whether desired changes persist after completing a course. Kagan suggests that concept maps and card sorting can only measure short-term changes that could ultimately be temporary and therefore of little value for understanding pedagogical content knowledge.

Teacher Education- An Amalgamation of Teaching Skills, Pedagogical Theory and Professional Skills

NCTE (1998) stated in Quality Concerns in Secondary Teacher Education, "The teacher is the most important element in any educational programme. It is the teacher who is mainly responsible for implementing the educational process in every stage." Hence, it is vital to invest in the preparation of teachers to secure the future of a nation. Solid and competent teachers have to be the crust of the nation's school system. The National Curriculum Framework 2005 places anxieties and expectations on the teacher to be addressed by initial and continuing teacher education.

The National Council for Teacher Education defines teacher education as an educational programme, research and training of individuals to teach from pre-primary to higher education. Teacher education is a programme related to developing teacher proficiency and competence that would enable and empower the teachers to fulfil the profession's requirements and face the challenges therein. From the academic perspective, teacher education means "all the formal and non-formal activities and experiences that help qualify a person to assume responsibilities of a member of the educational profession or discharge his responsibilities more effectively." The significant stakeholders of teacher education in India are (DIETs), CTEs and IASEs, with NCTE as the apex body.

Teacher preparation has changed from teacher training to teacher education by the end of the twentieth century. Teacher training had narrow goals with a focus mainly on just skill training. Therefore, the perspective of teacher education was fragile, and its scope was limited. As Kilpatrick put it, ―Training is given to animals and circus performers, while education is to human beings. Teacher education encompasses teaching, practical pedagogical theory and professional skills. Teaching skills would include providing training and practice in the different techniques, approaches, and strategies to help teachers plan and impart instruction, practical classroom management skills, provide appropriate reinforcement, and conduct a functional assessment. The pedagogical theory includes the philosophical, sociological and psychological considerations that would enable the teachers to have a solid foundation for practising the teaching skills in the classroom. The approach is stage-specific based on the necessities and requirements that are characteristic of that stage. Teachers need to develop professional skills like various techniques, strategies, and methods to help them grow and work towards the profession's growth. It includes soft skills, counselling skills, interactive skills, IT skills, information retrieving and management skills, and lifelong learning skills.

Nature of Teacher Education

Teacher education is a continuous process, and its elements of initial training and in-service training complement each other. According to the International Encyclopedia of Teacher Education and Training (1987), teacher training can be divided into initial training, induction, and in-service training. The three phases are viewed as part of an ongoing process. Teacher education is based on the saying that 'teachers are made, not born' instead of assuming that "teachers are born, they are not created". Since the class is viewed as an art and a science, the teacher must acquire knowledge and skills known as "Tricks of the Trade". It is constantly evolving and dynamic. For preparing competent teachers for the challenges of a dynamic society, teacher education must keep in step with the latest developments and trends.

The late 1980s and early 90s showcased major reforms in schooling, especially in science education. NPE (1986), calling for substantial improvement in teacher education, opinioned that teachers' status has diminished with time. Deterioration in their service conditions, the isolation in which teachers work, phenomenal expansion of the educational system, lowering of standards of teacher training, a general impression that a considerable number of teachers do not perform their duty correctly, changes in the value system in society are identified as the reasons for the deterioration. NCF (2005) believes that teacher education has not adequately supported attempts at curricular reform. Hence, teacher education must be sensitive to the emerging demands from the school system and must prepare the teacher for multiple roles. First, teacher education must enable student-teachers to understand the way learning occurs and create plausible situations conducive to learning. Second, allow student-teachers to view knowledge as personal experiences constructed in the shared teaching-learning context. Third, sensitising student teachers about the social, professional and administrative contexts. To ensure continuing professional development of teacher educators, the Justice Verma Commission (2012) recommended establishing inter-university centres of teacher education, restructuring teacher education programmes to improve the quality of teacher preparation, strengthening the regulatory and monitoring mechanisms and establishment of a performance appraisal system for teacher education institutions, teacher educators and school teachers. JVC report presented a holistic vision of teacher education in the country from the perspective of quality and regulation.

Following the vision of JVC, the National Council for Teacher Education (NCTE) revised its regulations, norms and standards for all teacher education programmes and notified new regulations on 1st December 2014. After that, the duration of the B.Ed and M.Ed programmes was enhanced from one year to two years. NCTE's Two-year B.Ed programme outlines the nature of student-teacher experiences to make them reflective practitioners. The course structure provides comprehensive coverage of themes and rigorous field engagement with the child, school and community comprising three broad inter-related curricular areas – a) Perspectives in Education, b) Curriculum and Pedagogic Studies, and c) Engagement with the Field. For getting an interdisciplinary perspective, all the courses alongside have in-built field-based units of study and projects. Engagement with the Field is the curricular element that holistically links all the courses across the programme. Special courses for Enhancing Professional Capacities (EPC) of the student teachers are also part of it. The programme's transaction is to be done using various approaches, such as case studies, group activities, projects, discussions on reflective journals, observations of children, and interactions with the community in multiple socio-cultural environments.

In India, secondary teacher education is mainly carried out in teacher education institutions affiliated with various universities. Although there are differences in teacher education programmes throughout the country, the commonalities outweigh the differences. Presently we have teacher education at the secondary level as a two-year graduate programme (B.Ed). The candidates who join teacher education programmes will have a bachelor's degree in a discipline. Altogether a novice teacher will have five years of university study, of which two years are under the faculty of education. In the case of postgraduates, the years of study will be seven years.

Graduates in Physics/Chemistry can opt for the Physical Science option during their B.Ed course for becoming Physics teachers. Candidates possessing B. Sc. with specialisation in Polymer Chemistry, Industrial Chemistry, Home Science/Geology with Physics/Chemistry as subsidiary subjects are also eligible for admission to the Physical Science option. Those who complete their B.Ed in Physical Science is qualified to teach physics and chemistry in secondary schools. To develop students' knowledge and comprehension of physics, teachers themselves need to understand the underlying meanings of facts, concepts, and procedures in physics. Knowledge of facts and procedures, concepts and connections, and knowledge of models and generalizations of teachers is very much topic-specific which stands as a deciding factor in student performance and interest in Physics. School studies reveal that among the teachers handling Physics in government secondary schools in Kerala, only 1/3 of them are physics graduates.

The nucleus of the entire process of teacher education lies in its curriculum, design, structure, organisation and transaction modes, and appropriateness. The teacher education curriculum has a sensitive knowledge base for field applications and needs like other professional education programmes. The knowledge base in teacher education is not just an admixture of concepts and principles from different disciplines, but a distinct gestalt emerges from the conceptual blending, making it specified. Teacher education is differentiated into stage-specific programmes. The knowledge base is adequately specialised and diversified across stages, utilised to develop effective processes of preparing novice teachers for the functions that a teacher is expected to perform in various stages. Teacher preparation involves an interdependence of Inputs, Processes and Outputs. The amalgamation of teaching skills, pedagogical theory and professional skills is essential to create the proper knowledge, attitude and skills in teachers, promoting holistic development.

The quality and development of a nation rely upon its citizens' quality. The quality of citizens depends on the quality of their education which hinges upon the quality of the teacher. Teachers' academic and professional standards constitute a critical component of the essential learning conditions for achieving educational goals. Teacher preparation has to shift from training to education if it has to positively influence the quality of curriculum transaction in classrooms, thereby pupil learning and the more extensive social transformation. The aspects like; the duration of academic preparation, the level and quality of subject matter knowledge, the range of pedagogical skills that teachers have to possess to fulfil the needs of various learning situations, the amount of commitment to the profession, sensitivity to contemporary issues and problems and the level of motivation need to be given greater emphasis. This will not happen if teacher preparation focuses only on the training. Holistic teacher upbringing is necessary, and therefore teacher education needs more emphasis than mere training. A central task of teacher education is helping teacher candidates critically examine their beliefs and values related to teaching, learning, and subject matter and developing a vision of good teaching to guide and inspire their learning (Fieman-Nemser, 2001). The teacher candidates entering teacher education have beliefs, values, commitments, personalities and morality from their family and schooling, influencing who they are as teachers and what they can learn in teacher education and teaching.

Teacher education is mainly concerned with four aspects, who (Teacher Educator), whom (Student teacher), what (Content) and how (Teaching Strategy). Teacher education relies upon the quality of teacher educators. The quality of pedagogical inputs in teacher education programmes and their effective utilisation to prepare prospective teachers depends mainly on the professional competence of teacher educators and utilising it for strengthening the teacher education programme. Hence, teacher education must first deal with the preparation of quality teacher educators. Teacher education provides student teachers with the relevant knowledge, attitude, and skills to perform effectively in their teaching carrier and equips the student teachers with the conceptual and theoretical framework to understand the niceties of the profession. Teacher preparation has to generate the necessary attitude in student teachers towards other stakeholders of the profession to approach the challenges constructively posed by the environment. Empowering the student teachers with the skills (teaching and soft skills) would enable them to carry on the functions most efficiently and effectively. Teacher education, therefore, has to pay attention to its content matter.

Reforms in Science Teacher Education

Science education has been subjected to many reforms, focusing on science curriculum and instruction. The first decade of the twenty-first century also witnessed reforms based on research on science standards in several countries. It is very enthusiastic that the research on science education focuses on science teacher education. The new curricular reforms and innovative instructional techniques need teachers to carry them out. Reforms in science teacher education are crucial for the success of other science education reforms. Teacher education reforms are driven by government policies, institutional initiatives, and science education researchers.

High-quality learning opportunities for students characterise good education. In this respect, "the teacher is the most important factor for student learning" (Abell, 2007). Therefore, improving education improves teachers' teaching competencies by providing high-quality learning opportunities in teacher education and professional development programmes. One of the significant challenges in designing these curricula and programmes is scaffolding teacher learning to be immediately relevant to practice (Borko, Jacobs & Koellner, 2010).

There is a coherent view that science education reforms primarily need to restructure science teacher education. The thought about the role of physics departments and how they support the education of physics teachers is evident in the beginnings of physics education research itself (Henderson et al., 2011). Physics teacher education is a clear and direct way for physics to improve the teaching and learning of physics in school. Difficulties in recruiting and training high-quality physics teachers have prompted researchers to develop and test several different approaches to physics teacher preparation (Singh et al., 2010; Thomaz & Gilbert, 1989). Researchers have investigated trainee physics teachers' learning of specific physics content (Aiello-Nicosia & Sperandeo-Mineo, 2000; Mäntylä & Koponen, 2007), trainees' difficulties and misconceptions in physics, as well as the epistemological development of prospective physics teachers (Ding & Zhang, 2016; Fazio et al., 2012). Not surprisingly, many student teachers expect to learn the "script" for science teaching and can be resistant to alternative perspectives (Britzman, 1991;

Hayward, 1997; Richardson, 1996). Thus, this issue is vital in shaping what it means to challenge student teachers' prior experiences to influence their science teaching practice.

According to physicists, traditional teaching methods at the university level are ineffective (Beichner, 2009; Harrison, 2010; Knight, 2004; Redish, 2003). The students can correctly answer traditional test questions without understanding the basic physics concepts or learning the practical concept-based problem-solving approaches (Wieman& Perkins, 2005); and a ten per cent level of retention after 15 minutes is typical for a non-obvious and counterintuitive fact presented in a lecture"(Wieman& Perkins, 2005). "To make science meaningful to students, teachers need to know how we know and what we know" (McDermott, 2006). Lederman and Lederman's (2004) discussion of HPS (history and philosophy of science) and NOS (nature of science) also share a similar view.

Science education research is intense with practical examples and studies in biology and chemistry but more negligible in physics. According to Lederman and Stefanich (2006), an effective teacher focuses on the science processes and their meaning much more than the product (Martin, 1997), focusing on the students' reasoning skills rather than accurate direct answers. The instructor's primary goal is to develop higher-order thinking skills in the learner, not disseminate information (Victory & Kellough, 1997; Zorfass, 1991). Regardless of education level, when students are unsuccessful, teachers need to re-examine their pedagogy: what they do and why it is not working (Lederman & Stefanich, 2006). The teacher education programmes in science have to focus on strengthening student-teachers subject matter knowledge and their ability to design various sorts of pedagogy most suitable for the context in which they practice.

Studies Related to Pedagogical Content Knowledge

Krepf, Ploger, Scholl, and Seifert (2020) studied the Pedagogical content knowledge of expert and novice teachers based on the knowledge they activate when analysing science lessons. The research aligned with Shulman's amalgam thesis, which assumed that participants activate their PCK by blending content knowledge (CK) and pedagogical knowledge (PK). They conducted an empirical study, assessing a videotaped lesson according to its effectiveness for learning. Nine experts and Nine novice teachers from Germany participated in the study. Participants were interviewed based on their analysis of the lesson from unit optics (law of refraction, Snell's law). Qualitative and quantitative evaluation of their interviews' showed that experts activated both CK and PK intensively and differed significantly from novice teachers. Further analysis of the expert statements proved that they do not activate their CK and PK in isolation but instead combine both kinds of knowledge, in line with Shulman's amalgam thesis.

Leuchter, Saalbach, Studhalter, and Tettenborn (2020) studied teaching for a conceptual change in preschool science: relations among teachers' professional beliefs, knowledge, and instructional practice. The study examined Swiss preschool teachers' competencies in supporting children's early science learning by examining the structure of preschool teachers' beliefs regarding learning and teaching, their pedagogical content knowledge, and their scaffolding practices. The sample comprised 104 Swiss preschool teachers with a mean age of 39 years (*min* = 20, *max* = 63). Five questionnaires were used to collect data. Items were designed to measure beliefs about science learning and teaching and their relation to their pedagogical content knowledge (PCK) and scaffolding practices within a curriculum about floating and sinking. Results suggest that preschool teachers who are motivated toward science and who feel a high degree of self-efficacy regarding science are more comfortable when modelling and clarifying tasks and procedures while using scaffolding practices that target children's higher-order thinking. The study suggests that teachers with a high motivational orientation toward science might need support to implement more advanced scaffolding techniques by building up more PCK and constructivist beliefs. Acquiring PCK of sufficient depth and quality to impact student learning lies at the heart of teacher education and professional development. The study notes that science teaching is not the acquisition of a 'bag of tricks' that transfers easily from master to apprentice as a set of agreed, general pedagogical practices; and that PCK continues to have value in providing insights about learning to teach science, which should affect how students learn science.

Kind and Chan (2019) studied PCK to inform how Shulman's (1987) 'amalgam' may be relevant to current researchers. The study tries to resolve the amalgam: connecting pedagogical content knowledge, content knowledge, and pedagogical knowledge, the development of CK, PK, and PCK in novice and experienced secondary science teachers, and how CK, PK, and PCK impact students' learning. For this, they reviewed five papers on PCK and discussed in detail the evidences regarding the relationships between content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK). The five papers illustrate differing perspectives on these types of teacher knowledge; all five provide empirical evidence and imply that CK and PCK are connected. They summarise their findings that the most successful teachers have flexible PCK that adapts quickly in classroom settings as they see students' varied responses to planned instruction. Such teachers will access instructional strategies which may be topic-specific or general pedagogical. Acquiring PCK of sufficient depth and quality to impact student learning lies at the heart of teacher education and professional development.

Keller, Neumann, and Fischer (2017) studied the impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. They examined how teacher knowledge and motivation affect students' achievement and interest. Classes of 77 physics teachers in Germany and Switzerland were investigated utilizing a multi-method approach. PCK test and achievement tests were used to measure teachers' PCK and students' achievements. Questionnaires were used to assess teacher motivation, student interest and student perceived enthusiastic teaching. Videotapes of classes were used to study cognitive activation. PCK test was focused on three dimensions: knowledge about common students' misconceptions and difficulties, knowledge about curriculum, and knowledge about the difficulty of tasks and contents. The data analysis showed that (i) teachers (with an average of 42% of items solved correctly) scored moderately well on the PCK test and cognitive activation was only at low to moderate levels (ii)Teachers' motivation and student-perceived enthusiastic teaching enthusiasm were moderate to high (iii) Students exhibited a moderate interest in Physics, (iv)students' interest and achievement are positively correlated to a small or moderate extent (v)PCK, and motivation are not related (vi)cognitive activation, and enthusiastic teaching are also not related to each other (vii)Teacher PCK was predictive of cognitive activation and cognitive activation, in turn, predicted students' achievement (viii) The effect from PCK on student achievement was low suggesting partial mediation. The findings highlighted that teacher pedagogical content knowledge mainly influences student learning, whereas teacher motivation influences students' interests.

Reddy (2017) studied teaching competency and pedagogical knowledge in relation to attitude towards the training of primary student teachers from Andhra Pradesh in India. The central research questions associated with the study are, what is the level of teaching competency of the primary student teachers? What is the level of pedagogical knowledge of the primary student teachers? Whether there is any significant influence on main effects, namely; locality, management, the subject opted for D.El.Ed admission and gender on the teaching competency of the primary student teachers? Six hundred forty primary student-teachers studying two years D.El.Ed course in all the four districts of the Rayalaseema region in Andhra Pradesh participated in the study. PCK test with 60 items prepared by the researcher was employed for measuring PCK. The pedagogical knowledge of the primary student teachers is positive because the mean score is greater than 50 per cent. The study's central finding showed a significant association between teaching competency and pedagogical knowledge at the 0.01 level of primary student teachers. Gender has a significant influence on the pedagogical knowledge of primary student teachers. Attitude towards training significantly influences the teaching competency and pedagogical knowledge of primary student teachers.

Rollnick (2017) studied how teachers teach a new topic and their role in PCK development. They studied how learning about semiconductors for teaching helped develop content knowledge and thus teachers' PCK. The research questions addressed were (i) How does teachers' CK develop while engaged in a project developing their teaching of semiconductors? (ii) What evidence of topic-specific professional knowledge and PCK in practice emerges in this process? 3. What evidence exists for the growth of teachers' PCK and its relationship to CK's new topic? Seven teachers registered for a part-time graduate qualification at a historically white research university in South Africa. Two supervisors assisted the teachers in acquiring new knowledge on semiconductors as part of their supervisory guidance. The teachers and their supervisors held three-hour weekly group meetings for 12 weeks, and various activities took place. Concept maps, journal notes, interviews, and project reports were used for data collection. This study identifies that a carefully scaffolded approach to teaching a new topic can develop PCK and CK. The study suggests the renewal of interest in teaching by teachers and an increased understanding of how teachers' learning of content is intrinsically bound to their vision of how it should be taught.

Wang and Buck (2016) studied high school physics teachers' pedagogical content knowledge of argumentation in the USA. They focused on two research questions; how did the teacher interact with these students differently after dialogic argumentation? How did the teacher describe his PCK regarding dialogic argumentation? The case study was conducted in a public high school located in a town with a population of 80,405. This high school had 1517 students from more than

28 countries. Jack, the cooperating teacher having 25-years of experience teaching physics, chemistry, and biology, was the subject of the study. This study was carried out in Jack's class, where there were 23 students, 14 males and nine females. Eighteen of the 23 students were 11th graders. The others were two 10th graders and three 12th graders. The physics content knowledge involved was classical mechanics for the fall 2013 semester and thermodynamics for the first half of the spring 2014 semester. This study lasted from October 2013 to March 2014. The study reveals that Jack did not perceive argumentation as a primary learning objective for all students to achieve because it places additional intellectual challenges beyond some students' abilities. Argumentation is only suitable for particular students who have mastered prerequisite skills or knowledge. Jack set up the norm of dialogic argumentation as authority-oriented to pursue and accept unique orthodox knowledge. The study summarises the findings as Jack's PCK of argumentation sheds light on the perception of argumentation by a high school science teacher who implements this educational innovation. Teachers need to avoid depriving students of their opportunities to engage in argumentation by over-inferring students' words or reasoning. The study infers that teachers' PCK development and professional development is a long-term and non-linear process; hence we should initiate it right from teacher preparation.

Kleickmann, Richter, Kunter, Elsner, Besser, Krauss, and Baumert (2013) studied Structural Differences in Teacher Education on Teachers' Content Knowledge and Pedagogical Content Knowledge. They conducted a cross-sectional comparison with German pre-and in-service mathematics teachers who were participants of Cognitive Activation in the Classroom (COACTIV) research at the Max Planck

Institute for Human Development, Berlin. The sample consisted of 243 mathematics teacher candidates and 539 student teachers recruited from universities in four cities (Berlin, Kassel, Kiel, and Flensburg). Used paper-and-pencil tests to evaluate prospective teachers' CK and PCK in mathematics. The CK test included 23 items from arithmetic, algebra, geometry, and functions. The items assess conceptual understanding of the contents of the secondary-level mathematics curriculum and require complex mathematical argumentation or proofs. The PCK test had three facets: students (11 items), instruction (17 items), and tasks (8 items). The study findings reveal that the first phase of teacher education plays a vital role in the development of CK, which is true in the case of science teacher education also. The learning opportunities in the pretraining phase contribute to this difference. Formal and nonformal learning opportunities during teacher education programmes are vital for developing CK and PCK. The study also says teaching experience alone is insufficient.

Mcneill and Knight (2013) studied teachers' pedagogical content knowledge of scientific argumentation: the impact of professional development on k–12 teachers. This study included 70 Grade K–12 teachers who attended the workshops from one large urban district in New England. All participants were provided with a draft version of a book focused on argumentation and explanation. The teachers were asked to read specific chapters between each of the meetings. Data from multiple sources were collected to evaluate teachers' initial PCK and determine whether or not their knowledge changed as they participated in the workshops. Data collection was focused on two elements of PCK (1) knowledge of students' conceptions and (2) knowledge of instructional strategies. The teacher assessment focused on knowledge of students' conceptions for argumentation, whereas the other data sources offered insights into both elements of PCK. What PCK do teachers have about scientific argumentation? How does their PCK of argumentation change while participating in professional development focused on this topic? The study's findings were: (i) future work should consider developing learning progressions for teachers' PCK of argumentation to enable the field to design more effective teacher education experiences over time (ii) Future research should examine different potential progressions for effectively supporting teachers in developing expertise in argumentation(iii) future professional development has to consider different design principles or heuristics for professional development targeting elementary, middle, or high school teachers (iv) professional development can support teachers in developing more significant expertise around argumentation.

Azma and Talebinejad (2012) investigated the relationship between teachers' pedagogical knowledge and students' success. One hundred ninety-seven students and 15 teachers in the intermediate level participated in the study. To measure teachers' pedagogical knowledge, the researcher used a valid and reliable test. The test had 16 multiple-choice questions. The purpose of the study was to measure teachers' pedagogical knowledge. After collecting data, the researcher used descriptive and inferential statistics to interpret the data. The results show a significant relationship between teachers' pedagogical knowledge and students' success.

Schneider and Plasman (2011) examined the research on science teachers' pedagogical content knowledge (PCK) to refine ideas about science teacher learning progressions. This review examined the research across 25 years since conceptualising pedagogical content knowledge as a construct for teacher knowledge. The study focused mainly on: How do science teachers' thinking regarding PCK progress over time with experience in the classroom? What variables appear to influence science teachers' knowledge progression regarding PCK? Summaries of each article in the data set obtained from educational databases like ERIC, Educational Full Text, Educational Research Complete, EBSCO host, and Academic Search Complete were written by closely examining the significant findings regarding science teacher PCK. Teachers' experience in teaching science, grade level, the number of teachers studied, and the research approach used were also noted. The study findings showed that PCK is still a developing construct based on researchers' and philosophers' ideas about professional knowledge. More empirical work is needed to define this construct to understand and enhance teachers' knowledge. Educational opportunities for teachers need to begin with preservice education and continue with the same concern for developing teachers' thinking throughout their careers.

Kaya (2009) studied the nature of relationships among the components of pedagogical content knowledge of preservice science teachers. The primary aim was to study relationships among the components of Pre-service science teachers' (PSTs) pedagogical content knowledge (PCK) related to ozone layer depletion. Two hundred sixteen students (118 females and 98 males, aged 21–23 years) in their final year (fourth year of their undergraduate degree) enrolled in science teacher education programmes at two universities in Turkey participated in the study. A five-item open-ended survey was used to determine the PSTs' conceptual understanding of ozone layer depletion. The survey focused on these five main areas involving ozone layer depletion as follows: nature of ozone layer, causes of ozone layer depletion, consequences of ozone layer depletion, functions of ozone in the stratosphere, and relationships among ozone layer depletion, global warming, and acid rain. The alpha reliability coefficient of the survey was 0.87. A semi-structured individual interview was used to determine the PSTs' pedagogical knowledge on ozone layer depletion. PSTs' responses to the open-ended survey and interview questions were assessed based on the same three knowledge categories (appropriate, plausible, and naive). A scoring rubric was prepared for the assessment of the interview. The inter-relationships and intra-relationships among the components of the PSTs' PCK were investigated using the Pearson product-moment correlation coefficient. Multivariate analysis of variance (MANOVA) was conducted to explore the impact of the level of PSTs' subject matter knowledge on their pedagogical knowledge and its components. The results showed that, on average, 101.40 (46.94%) PSTs had naive, 52.80 (24.44%) PSTs had plausible, and 61.80 (28.61%) PSTs had a proper understanding of the topic of ozone layer depletion. A comparison of the mean ($M = 6.23$, $SD = 5.70$) of all 216 PSTs' total scores with the maximum value of 17.50 of the survey indicated a success rate of 35.60%, which is low.

In Sweden, Drechsler and Van Driel (2008) studied teachers' knowledge of students' difficulties in understanding acid-base chemistry and their knowledge of teaching strategies (especially their use of models of acids and bases) in their teaching practice. Nine preservice chemistry teachers enrolled in the specific course under study were interviewed two years after completing the course. Interview Questions were about their planning of an acid-base lesson sequence and how they changed their teaching from year to year, about textbooks they used (excerpt from the books discussed), about students' difficulties regarding acid and bases (commenting on previously recorded teaching), and about their satisfaction with development for teaching acid-base (as a storyline). Teachers showed some development in PCK for teaching acid bases. They were categorised into two groups: students-model orientated (focused more on students' difficulties and explanations) and teacher orientated (focused on teaching strategies and new activities).

Ozden (2008) in Turkey studied the effect of the amount and quality of content knowledge of student teachers on their PCK in the context of preparing lesson plans. The topic selected for study is phases of matter from Chemistry. A qualitative study with a Case Study approach was employed on 28 science student teachers enrolled in the department of primary science education. Data from three resources (lesson plan, CKT and semi-structured interviews) were categorised into main categories and subcategories to analyse student teachers' content knowledge, conceptual understanding, knowledge of curriculum, teaching methods, and their orientations towards teaching science. Findings showed that content knowledge has a positive effect on PCK.

Krauss, Brunner, Kunter and Baumert (2008) examined the two knowledge types' level and connectedness in two groups of teachers with different mathematical expertise. The study was conducted at the secondary level, and 198 mathematics teachers in Germany participated in the study. Data were collected by administering PCK Test and CK test individually, and it took 2 hours to complete the tests (65 minutes for the PCK test and 55 minutes for the CK test). PCK test contained three parts: knowledge of mathematical tasks (4items on multiple paths to solution), knowledge of student misconceptions and students' difficulties (7 scenario-based items), and knowledge of mathematics-specific instructional strategies (10 items to explain mathematics situations). In CK Test, 13 items were constructed to cover relevant content areas. (e.g., arithmetic, algebra, and geometry) and to tap conceptual or procedural skills. All items were open-ended. The results showed that teachers with higher CK also tend to have higher PCK.

Lee and Luft (2008) explored the concept of PCK with experienced mentor teachers. Pedagogical content knowledge is composed of Knowledge of science, Knowledge of goals, Knowledge of students, Knowledge of curriculum organisation, Knowledge of teaching, Knowledge of assessment, and Knowledge of resources. Four experienced teachers participated in this study; they were identified through purposeful sampling. Participants had at least ten years of teaching experience and three years of experience in mentoring. A constant comparison method was employed. Seven components (knowledge of science, goals, students, teaching, curriculum organisation, assessment, and resources) were common to all four participants, with slight variations in specific elements.

Park and Oliver (2008) studied the Conceptualisation of Pedagogical Content Knowledge (PCK): PCK as a Conceptual Tool to Understand Teachers as Professionals. This study aimed to re-examine the construct of PCK based on empirical research with experienced high school teachers. This study was a multiple case study of three experienced female chemistry teachers working in the same high school, Chattahoochee River High School. Data was collected from multiple sources, including classroom observations, semi-structured interviews, lesson plans, teachers' written reflections, students' work samples, and the researcher's field notes. All interviews and observations were audiotaped and transcribed verbatim. The teachers were also asked to write reflections on their teaching. The data were analysed through three different approaches: (a) constant comparative method, (b) enumerative approach, and (c) in-depth analysis of explicit PCK. Findings show that (a) teacher efficacy was evident as an affective affiliate of PCK; (b) students influenced the ways that PCK was organized, developed, and validated; (c) teachers' understanding of students' misconceptions was a significant factor that shaped PCK in planning, conducting instruction, and assessment.

Van Drial and Verloop (2008) investigated the development (change) of PCK of teachers over three years after introducing a new curriculum in the context of teaching a chapter on the solar system. Nine teachers working in five different schools in the Netherlands, who have completed a one-year course to teach, participated in the study (3 teachers each from Physics, Chemistry, and Biology). According to the findings, two types of PCK with regard to Models of the Solar System and the Universe were identified: Type A and Type B. Finally, a combination of codes applied per teacher was examined over the years to find how different types of PCK developed. Focusing on the relationship between the different PCK elements indicates that Type A and Type B of PCK developed qualitatively differently.

Drechsler and Van Driel (2008) studied the variation of Swedish chemistry teachers' ideas about teaching acids and bases, focusing on using various models in the upper secondary level. Data were collected through a Questionnaire from 441 upper secondary schools, and 281 teachers participated in the study. The questionnaire was a Likert type scale and was developed in two parts; Part 1: Teacher variables (age, sex, experience, academic qualification and what textbook they used, type of employment, other subjects they teach). Part 2: consisted of 31 items about the teaching of acid and bases, covering three issues; (i)- teachers' knowledge of students' difficulties in learning and teaching acid and bases, (ii) – teachers' knowledge of the Bronsted and other models of acid and bases, and their use in teaching, and (iii) - teachers' views on their textbook focusing on teaching models of acids and bases (Item statements were based on the findings of two interview studies on the same topic). Results showed that the respondents preferred to use the Bronsted Model and thought that the Bronsted model was clear for students (BM scale). However, their knowledge about how the Bronsted model differs from the Arrhenius model was limited and diverse (CK scale).

Johnston and Ahtee (2006) explored the connection between teacher's attitude, subject knowledge and the construction of PCK in initial teaching. 98 English and 98 Finnish primary science student teachers who had studied physics and chemistry only until high school finished 50 hours of lectures, seminars, and workshops developing scientific knowledge and PCK over the previous two years and spent 12 weeks on school placement participated in this study. Findings showed a link between these student teachers' attitudes and their confidence in teaching Physics, but this confidence is not necessarily well-founded and results from, and results in, good

SMK and PCK. There is a need to develop positive attitudes toward Physics and better understand SMK qualitatively and not quantitatively.

De Jong, Van Driel and Verloop (2005) from the Netherlands studied the development of PCK (use of particle models) in the context of a specific course module within a chemistry teacher education program. Before entering the teacher education program, twelve preservice chemistry teachers with Master of Chemistry degrees participated in a ten-week course module program. The findings showed that preservice teachers further develop their PCK using particle models, although this development of PCK varied from teacher to teacher.

Loghran, Mulhall and Berry (2004) developed a research approach to access and portray the PCK of science teachers. The study was conducted on 24 high school Australian teachers with diverse science backgrounds (Physics, Chemistry, Biology). Data were collected through individual interviews, weekly classroom observations, and small (3 or 4) group workshops for developing content representation (CoRes). Successfully developed a new approach for accessing and representing PCK of science teachers in the form of Content representations (CoRes) and Professional and pedagogical experience repertoire (Papers).

Van Driel, De Jong and Verlopp (2002) investigated the development of PCK of preservice teachers during a semester of their postgraduate teacher education program and how this is influenced by teaching experience, institutional workshops, and the mentor. Twelve preservice chemistry teachers (all M.Sc.) in a one-year postgraduate teacher education program from the Netherlands participated in the study. The study focused on prospective teachers' concerns about teaching a major topic in science education, i.e., linking macroscopic phenomena with microscopic particles and symbolic representations such as formulas and equations. A qualitative study and a multi-method approach were employed. The results showed that growth in PCK was indicated by increased awareness about relating macro and micro levels to each other and consistent use of language. The growth of PCK was influenced by teaching experience, workshops in university and talking with mentors.

Van der Valk and Broekman (1999) developed a method (lesson preparation) for the Oslo Maths Project to investigate PCK. Furthermore, see how this method simulates preservice teachers to show their ability to develop PCK. Five preservice maths teachers and five preservice physics teachers enrolled in a two-week postgraduate orientation to teaching course in a Dutch university participated in the study. Data were collected through a course assignment (Lesson Planning) and an interview (conducted in two parts: first stimulating discussion followed by a question about five aspects of PCK). The lesson preparation method developed by this Oslo Maths Project was considered valid because it makes teachers express their PCK. The lesson preparation method was recommended to be useful for other subjects, including science.

Van Driel, Verloop and De Vos (1998) studied the development of teachers' PCK for a specific topic (i.e., chemical equilibrium within the context of an in-service program). Twelve experienced chemistry teachers (with more than five years of experience in teaching chemistry in upper secondary) with a background in chemistry from the Netherlands participated in the study. The findings identify teaching experience as the primary source of PCK, whereas adequate subject matter knowledge (SMK) appears to be a prerequisite.

Clermont, Borko and Krajcik (1994) examined the PCK of experienced and novice chemistry demonstrators (middle and high school) in the USA. Seven novice and five experienced chemistry demonstrators participated in the study. The results further support the presence of cognitive differences between experienced and novice teachers with respect to their pedagogical content knowledge and pedagogical reasoning.

Even (1993) investigated the interrelations between teachers' content knowledge and PCK related to two essential features of the concept of function, arbitrariness, and ambivalence among 62 prospective secondary mathematics teachers in the last stage of their preservice preparation from nine universities in Israel. One immediate conclusion of the study is that an important step in improving teaching should be better subject matter knowledge (SMK) preparation for teachers.

Marks (1990) conducted a qualitative study among Eight teachers (six experienced and two novices) from the USA to present a description of PCK in mathematics to suggest modifications in the general conception of PCK. Task-based interviews (8 tasks) for 45 and 90 minutes were employed. The tasks focused on fifth-grade mathematics teaching and included planning a lesson, analysing a classroom videotape, and diagnosing and remediating students' errors. All interviews were transcribed in full (Initially, 900 selections were made for texts portions based on a single idea and then reduced to two to three-line texts). The constant comparison method (Glaser & Strauss, 1967) was used, and then data were coded, which resulted in 12 categories. These were decomposed into four hierarchical levels of categories and then synthesised into a coherent structure that included the three primary knowledge categories; Knowledge of subject matter, general pedagogy and PCK. Pedagogical content knowledge comprises four areas: subject matter for instructional purposes, students' understanding of the subject matter, media for instruction, and instructional procedures for the subject matter. A model to represent PCK of 5th-grade mathematics equivalence of Fractions was developed based on the data to define pedagogical content knowledge and identify its sources.

Carpenter, Fennema, Peterson, and Carey (1988) studied the status of teachers' pedagogical content knowledge (PCK) and the relationship between their knowledge and students' achievement in the USA. The sample comprised 40 teachers from 27 schools with approximately ten years of teaching experience in elementary schools. They found that the teachers' ability to predict students' success in solving different problems was significantly correlated with students' performance on both the number-fact and problem-solving tasks. Teachers' ability to predict students' strategies to solve different problems was not significantly correlated with measuring student performance.

Conclusion of Literature Review

Knowledge base for teaching encompasses various types of teacher knowledge

The knowledge base of teaching enables us to say what we are teaching and assessing and what we are not. Shulman introduced the idea of the knowledge base for teaching to define the professional knowledge base for teachers, the knowledge base for teaching was also used to describe the knowledge base of teaching. The knowledge base for teaching is also "The Knowledge Base for Beginning Teachers" (Reynolds, 1989). Knowledge base for teaching is of much importance in the teacher preparation programmes (Reynolds, 1992), encompassing the various types of teacher knowledge required for teachers to teach. The knowledge base for teaching comprises seven knowledge categories: content knowledge, learners and learning, curricular knowledge, knowledge of contexts, general pedagogical knowledge, knowledge of goals, and pedagogical content knowledge. This point of view encouraged a review of teacher education and opened a debate in teacher education communities about teacher knowledge and thinking. The idea of the knowledge base for teaching helps design teacher education based on existing frameworks. It is a dynamic concept that constant evaluation is needed to respond to the latest developments in this area. While recognising teaching as a profession, the teacher's knowledge must be taken into account by "(a) the type of knowledge required and the relationships between the identified knowledge categories, (b) the conceptual framework for the organisation and use of knowledge and c) the research methods used to create and validate knowledge claims in this area (Strom, 1991).

Darling-Hammond (2006) suggested that teacher training should focus on the "close link between theory and practice, course work and clinical work" to build a professional knowledge base for teaching. Each teacher has a "personal knowledge base" of teaching that defines their practice, which differs from the knowledge base for teaching. A teacher's knowledge is also the knowledge base of teaching, as it emerges from actual teaching, unlike the term knowledge base for teaching, which commonly defines the knowledge required for teaching.

A teacher's knowledge base is also described in terms such as practical knowledge (Elbaz, 1981, 1983), personal knowledge (Lampert, 1985), experiential knowledge (Clandinin, 1985, 1988), and practical knowledge (Clandinin & Connelly, 1995, 1996). We can call "teacher knowledge" the personal knowledge base of education.

The knowledge base for teaching is a broader perspective that encompasses various aspects of the knowledge needed for teaching in general, while the knowledge base of teaching is individual teachers' knowledge used for teaching. Teachers develop their knowledge through the act of teaching - something they called "practical knowledge" - and have proposed five dimensions of knowledge: (i) Subject matter, (ii) instruction, (iii) curriculum, (iv) self and (v) teaching milieu (environment). This knowledge is subject to change based on personal experiences inside and outside the classroom. Terminologies used to describe teachers' knowledge are the wisdom of practise (Schwab, 1971), professional knowledge (Tom &Valli, 1999) and professional craft knowledge (Brown & McIntyre, 1986).

Introduction of Pedagogical Content Knowledge" (PCK) by Shulman (1986, 1987) initiated and contributed to the debate on teachers' knowledge by presenting a new vision of the study of teaching centred on the subject taught. He presented his views on the knowledge base for teaching and the seven categories in this knowledge base. Pedagogical Content Knowledge (PCK) is considered crucial in differentiating a teacher from a content specialist. He classified the research literature on teacher knowledge into two study areas: (a) the knowledge that teachers generate based as a result of their experience of classroom teaching - in other words, practical knowledge, and (b) knowledge about teaching that is generated by those who specialise in research on teaching which is formal knowledge and that can be generalised across various contexts. Teacher knowledge can be classified as "knowledge for teaching" and "knowledge about teaching". Teacher knowledge comprises the formal, theoretical or scientific form of knowledge that differs from certain other types of knowledge that are otherwise known as practical knowledge, craft knowledge, knowledge, received wisdom, practical wisdom, acquired wisdom or experience, personal and practical, localized, relational, embodied popular or tacit knowledge.

Pedagogical content knowledge is an amalgam of subject knowledge, general pedagogical knowledge, and contextual knowledge

Pedagogical Content Knowledge (PCK) is the specialist knowledge teachers require to teach specific content, a teacher's primary responsibility. PCK is a unique amalgam of content and pedagogy reserved exclusively for teachers and their form of understanding. PCK stand as an independent knowledge base for teaching that is a mixture of content and pedagogy to understand how specific topics, problems and topics are organised, presented and adapted to the different population of learners and presented for instruction. There is a clear link between the PCK and other types of teacher knowledge, including subject knowledge, general pedagogical knowledge, and contextual knowledge. The sources of PCK are observations in the classroom as students and during teacher training in the workplace, scientific studies, teacher training programmes and personal teaching experience. Pedagogical Content Knowledge is vital to teacher knowledge and is essential for teaching.

Teachers' knowledge is practical, develops over years of experience, and deals with how they have accumulated the "wisdom of practice" This argument indicates the experiential and practical nature of PCK. PCK has value or beliefs components and has a subject matter component, a purpose component, a pedagogy component and other components. Cochran-Smith and Lytle (1998) suggested that pedagogical content knowledge is a term that can reduce the dualism of practical and formal knowledge.

Magnusson et al.'s (1999) model of PCK identified five components of knowledge that are connected in some hierarchical way: (i) Orientation to science teaching, (ii) Knowledge and beliefs about the science curriculum, (iii) Knowledge and beliefs about students' understanding of specific science topics (iv) Knowledge and beliefs about instructional strategies for teaching science and (v) Knowledge and beliefs about assessment of science and also described the relationships between these five aspects of knowledge providing a more detailed description of each.

Lee and Luft (2008) identified seven knowledge components that contribute to the science PCK of science teachers: 1. Knowledge of science 2. Knowledge of goals 3. Knowledge of students 4. Knowledge of curriculum organisation 5. Knowledge of teaching strategies 6. Knowledge of assessment 7. Knowledge of resources. Roles of teacher qualifications, their particularities and considerations, reflection in action and reflection on action are also studied as part of PCK.

Science teachers' PCK includes knowledge of students' thinking about the nature of science, science curriculum, specific instructional strategies for science, assessment of students' science learning, and orientations to teaching science. PCK is an amalgamation or transformation (not an integration) of subject matter, pedagogical, and context knowledge. Cochran-Smith and Lytle (1998) suggested that PCK should be transformed to help preservice science teachers learn how to teach science effectively. Giving student teachers proper training for PCK development as part of their pedagogy course will be much more effective during the teacher education programme. PCK is a heuristic for teacher knowledge; it can help reduce the convolutions of what teachers know about teaching and its vicissitudes over a long period. It is vital to identify practical and innovative ideas in teacher preparation programmes to seed a comprehensive idea about PCK in prospective teachers early in their careers.

Pedagogical content knowledge is implicit

The literature shows an ongoing deliberation about structural clarification of PCK, which mainly relates to the knowledge components contained in PCK and relationships. Many teachers find it difficult to express their personal and practical knowledge. There is a common belief that teachers' knowledge is tacit. Thus, it is problematic to make it explicit. Kennedy (1998) argued that PCK "must be explicit rather than tacit”. The nature of pedagogical content knowledge itself is not explicit. The construct of PCK lacks clarity both structurally and philosophically. The researcher’s definitions of pedagogical knowledge (PK) also exhibit variation. The Pedagogical Content Knowledge (PCK) construct has been used inconsistently, and many of its features are overlooked by researchers.

Even after substantial research into science teacher knowledge, the notion of PCK introduced by Shulman (1986, 1987) has still not reached a clear, agreed-upon definition among researchers (Abell, 2007; Berry, Loughran & van Driel, 2008). PCK is partly an internal construction; it is the teacher's understanding of the content-specific examples that best represent specific topics and the knowledge of the students' common difficulties with specific topics—studying a teacher's knowledge of the "best examples". We cannot rely solely on observational data, and a teacher may use only a limited portion of their stock of examples during a particular lesson. As observers, we will have no idea which examples the teacher did not use. The structure of the PCK needs to get more clarity, and it is necessary to draw a clear and complete picture of the PCK in various disciplines.

Pitjeng-Mosabala and Rollnick (2017) argue for ‘differentiating PCK in knowledge and practice’ and note differences between ‘personal’ and ‘canonical’ PCK. Meanwhile, Liepertz and Borowski (2018) acknowledge personal PCK, proposing that teachers draw on PK, CK and PCK separately to create personal teacher knowledge. The nature of the pedagogical content knowledge itself is less delineated. Teachers generate PCK from a variety of sources; prior experiences as students, imitating more skilled teachers, discussion and instruction from colleagues, and distinctive practices that a teacher generates alone. The PCK definition must be sufficiently flexible to be applied in the range of situations and frameworks in and from which teachers work and learn. In order to make PCK explicit, it has to be transformed into a composite knowledge derived from teachers' other knowledge bases. Stronger connections lead to better quality PCK. PCK varies depending upon students, context, environment and depth of knowledge held by a teacher. Any research on Pedagogical Content Knowledge conducted without a deep understanding of the PCK construct can lead to different interpretations that can lead to limited or misleading effects. Therefore, it is crucial to understand PCK as a whole in order to evaluate it.

Pedagogical content knowledge is topic-specific

PCK is "an independent knowledge base for teaching that is a mixture of content and pedagogy to understand how certain problems and topics are organised, presented and adapted to the different population of learners and presented for instruction". Magnusson et al. (1999) conducted an extensive analysis of the literature on PCK and proposed a theoretical conceptualization of it for science teaching. Their visual model of science PCK provided an expanded view of the pedagogical content knowledge of science. Park and Oliver (2006) studied the PCK of chemistry teachers who taught various chemistry subjects and found a more coherent representation of their PCK. This representation of the science PCK of chemistry teachers can represent their domain-specific science PCK. Most of the topic-specific science PCK research has examined selected pieces of knowledge from the science teachers' PCK, which has not contributed much to the understanding and development of the construction of the PCK. Van Driel et al. (1998) consider that PCK is essentially topic-specific knowledge and have developed a research programme to provide examples of topic-specific science PCK in various curricular topics. His research contributed to the discussion of PCK but did not offer a new model and instead relied on various definitions existing in the research literature.

Loughran and his team also believed that PCK was essentially topic-specific knowledge. Their research has documented the topic-specific science PCK of science teachers in various curriculum areas (Loughran et al., 2001, 2004, 2006). While they made significant contributions toward understanding the topic-specific PCK of science teachers and the knowledge base of science teacher education, they did not elaborate on the existing PCK models at the time. They preferred to employ their own unique approach to study and document topic-specific science PCK. This aspect of topic-specific PCK is composed of the knowledge of the ideas and topics and how they are organised that secondary school students need to learn to understand these topics. Teachers' conceptual knowledge of various science topics and the related knowledge and subject matter knowledge understanding contribute to their topic-specific PCK. Teaching pedagogical content knowledge is considered essential (Fenstermacher, 1994; Shulman, 1987) because it focuses on "teaching specific content" included in the school curriculum. Shulman (1986) presented PCK as the expertise that distinguishes the true teacher from a content specialist and thus captures the knowledge necessary for effective teaching. He also asserted that the teacher's teaching knowledge was focused on particular topics; thus, PCK is called topic-specific knowledge. Researchers have investigated trainee physics teachers' learning of specific physics content (Aiello-Nicosia & Sperandeo-Mineo, 2000; Mäntylä & Koponen, 2007), trainees' difficulties and misconceptions in physics, as well as the epistemological development of trainee physics teachers. Researchers from various disciplines have also examined the influence of PCK on teachers' beliefs, classroom practice and student understanding. It can be found that research on topic-specific science PCK has not considered it essential to use science PCK models to frame their research or develop their models of topic-specific PCK.

Pedagogical content knowledge can be assessed using multi-method techniques

Shulman (1987) asserted the importance of the subject matter for teaching and PCK and initiated a reform in teaching assessments. provided a vision of "assessment of teaching that faithfully reflects its complexity, and for this purpose, he recommended using multiple assessment strategies that he called "a union of insufficiencies." A substantive portion of the research on science researchers and teacher educators has developed various methods and techniques for examining PCK, such as paper and pencil tests (especially multiple-choice tests), concept maps, visuals, interviews and multi-method evaluations. These techniques have served purposes such as teacher appraisal, staff development, and curriculum development. Summary of research on the assessment of PCK identifies several techniques: card-sorting tasks (Shulman, 1987), concept maps (Morine-Dershimer, 1989), and lesson study methods (Van der Valk & Broekman, 1999), and open-ended questions (Gess-Newsome & Lederman, 1993). More recently, multi-method techniques using interviews, classroom observation, and reflection by teachers have been used to understand PCK for teaching science (Lee & Luft, 2008; Loughran et al., 2004).

The studies can be categorised into three groups: (a) convergent and inferential techniques. (b) concept mapping, card sorts, pictorial representations, and (c) multi-method evaluations. Convergent and inferential techniques include Likert-type scales, multiple-choice items, and short answer formats. All of these formats use pre-established verbal descriptions of the knowledge teachers want as a benchmark for comparing the verbal responses of teachers in training and the workplace. Kromrey and Renfrow (1991) used multiple-choice test items to measure content-specific pedagogical knowledge (C-P). They consider content-specific pedagogical knowledge separate from content knowledge and general pedagogical knowledge; their construct, C-P, certainly sounds similar to pedagogical content knowledge with a slight variation in the label.

Teacher education enables to view knowledge as personal experiences constructed in the shared context of teaching-learning

Teacher education is a programme related to developing teacher proficiency and competence that would enable and empower the teachers to fulfil the profession's requirements and face the challenges therein. Teacher education encompasses teaching, practical pedagogical theory and professional skills. It is constantly evolving and dynamic. In order to prepare competent teachers for the challenges of a dynamic society, teacher education must keep step with the latest developments and trends. Teacher education must enable student-teachers to understand the way learning occurs and create plausible situations conducive to learning. Second, enable student-teachers to view knowledge as personal experiences constructed in the shared context of teaching-learning. Third, sensitizing student-teachers about the social, professional and administrative contexts.

In India, secondary teacher education happens in teacher education institutions affiliated with various universities. Although there are differences in teacher education programmes throughout the country, the commonalities outweigh the differences. The nucleus of the entire process of teacher education lies in its curriculum, design, structure, organisation and transaction modes, and appropriateness. The teacher education curriculum has a sensitive knowledge base to field applications and needs like other professional education programmes. The knowledge base in teacher education is not just an admixture of concepts and principles from other disciplines, but a distinct gestalt emerges from the conceptual blending, making it specified. The aspects like; the duration of academic preparation, the level and quality of subject matter knowledge, the range of pedagogical skills that teachers have to possess to fulfil the needs of various learning situations, the amount of commitment to the profession, sensitivity to contemporary issues and problems and the level of motivation need to be given greater emphasis. Holistic teacher upbringing is necessary, and therefore teacher education needs more emphasis than mere training. Teacher education is mainly concerned with four aspects, who (Teacher Educator), whom (Student teacher), what (Content) and how (Teaching Strategy). Teacher education relies upon the quality of teacher educators. The quality of pedagogical inputs in teacher education programmes and their effective utilisation to prepare prospective teachers depends mainly on the professional competence of teacher educators and how it is utilised for strengthening the teacher education programme. The primary purpose has to be empowering the student teachers with the skills (teaching and soft skills) that would enable them to carry on the functions most efficiently and effectively. Teacher education, therefore, has to pay attention to its content matter.

Teacher education reforms are driven by government policies, institutional initiatives, and by science education researchers. Science education has been subjected to many reforms, focusing on science curriculum and instruction. The first decade of the twenty-first century also witnessed reforms based on research on science standards in several countries. It is very enthusiastic that the research on science education is focusing on science teacher education. The new curricular reforms and innovative instructional techniques need teachers to carry them out. Improving education is served by improving teachers' teaching competencies by providing high-quality learning opportunities for teachers in teacher education and professional development programme. One of the significant challenges in designing these curricula and programmes is scaffolding teacher learning to be immediately relevant to practice (Borko, Jacobs & Koellner, 2010). The issue with teacher education programmes is the disconnect between what teachers know based on their practice (practical knowledge) and what student teachers need to know to become competent teachers (formal knowledge). There is a coherent view that science education reforms primarily need the restructuring of science teacher education.

We need to foster science teacher education. It's an important problem. Science education has to be provided by teachers who are intensively involved with the intellectual processes of the natural sciences and who have scientific content and the ability to impart a variety of complex experiences with the natural sciences to students. There seems to be a significant mismatch between this vision and the preparation that preservice science teachers are currently receiving. The second important problem is that we could not find so much detailed information about this preparation. This study attempts to understand the factors that influence the PCK among prospective science teachers in current practice.

METHODOLOGY

The methodology involves various tools, techniques and methods adopted by a researcher while undertaking research. The validity and reliability of the research findings mainly depend upon the methods adopted for the study. The researcher has to follow a systematic and scientific methodology while addressing a research problem. The primary goal of this study is to examine the factors that influence Pedagogical Content Knowledge (PCK) in Physics among secondary school teachers. The methodology in detail is explained below under the headings.

Variables

Objectives

Design of the Study

Tools Used for the Study

Sample Selected for the Study

Data Collection Procedure, Scoring and Consolidation of Data

Statistical Techniques Used for Analysis

Variables

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes (Best & Kahn, 2016). In the present study, Pedagogical Content Knowledge in Physics is treated as the dependent variable. It has three dimensions viz., Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK). The study also has nine independent variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Teacher Motivation, Attitude towards Science and Self-efficacy. Two classificatory variables in the study are Gender and Level of Physics studied.

Objectives

1. To find out the extent of Pedagogical Content Knowledge (PCK) in Physics among prospective secondary school teachers and their sub-groups based on

    a. Gender, and
    b. Level of Physics studied.

2. To find out the extent of the relationship between each of the institutional and learner related variables and PCK in Physics among prospective secondary school teachers and their sub-groups based on

    a. Gender, and
    b. Level of Physics studied

3. To identify the significant institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and sub-groups based on

a. Gender, and

b. Level of Physics studied

4. To develop a regression equation for predicting PCK in Physics among prospective secondary school teachers and their sub-groups with the select institutional and learner related variables.

5. To find out the relative efficiency of the select institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and their relevant sub-groups.

Hypotheses

1. There will be a significant relationship between each of the select variables and PCK in Physics for the total group and sub-groups based on

   a. Gender, and

   b. Level of Physics studied

2. PCK in Physics among prospective secondary school teachers can be significantly predicted from the select set of institutional and learner related variables.

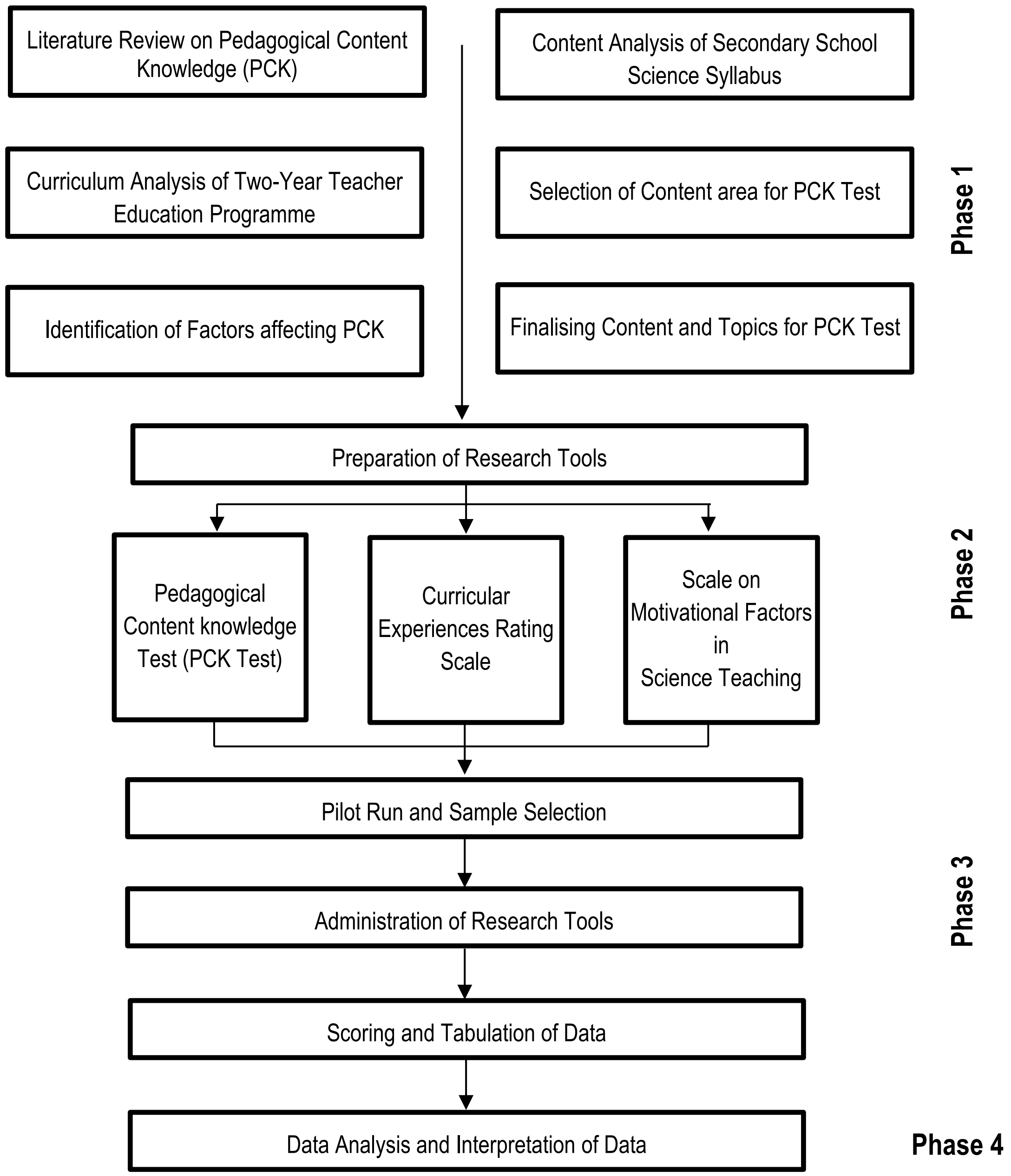
Design of the study

"A research design is the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy and procedure" (Jahoda, Deutsch & Stuart, 1951). Quantitative research design is adopted for this study. The quantitative method helped to understand the cause-effect relationship and influence of select variables in the B.Ed programme on the Pedagogical Content Knowledge in physics among prospective secondary school teachers.

The study is conducted in four phases: In the first phase, a thorough analysis of the current two-year B.Ed programmes in four different universities in Kerala and content analysis of secondary school physics curriculum for 8, 9, 10, 11 and 12 classes were done. The second phase comprises the construction of research tools intended to collect the relevant data from the prospective secondary school teachers. Administration of tools, data collection and tabulation of data constitutes phase three of the study. Phase four is the analysis and interpretation of data. An outline of the methodology is given in Figure 1.

Figure 1

Outline of the Total Procedure



In the initial phase, the researcher analysed the two-year B.Ed programmes of the various Universities of Kerala, considering all aspects that will influence the professionalism and competency of a prospective science teacher in teaching secondary school Physics as a subject. As the best possible resource, the researcher settled on expert physical science teacher educators and other curriculum experts to collect the required information. Discussions were conducted among the expert faculties of education, especially physical science teacher educators of the University of Calicut. The researcher's experience as a physical science teacher educator was also handy in gathering the required information essential for the initial stages of research. The discussion with the senior secondary school teachers and review of the literature was employed by the researcher in selecting the content area for constructing the Pedagogical Content Knowledge Test. The contributions from the senior experienced in-service teachers were handy in understanding the current practices in schools, the nature of students' learning, and selecting the content area.

Based on the information collected in the first phase, comprehensive tools were constructed to collect the required data from prospective secondary school teachers, namely, Pedagogical Content Knowledge Test, Curricular Experiences Rating Scale and Scale on Motivational Factors in Science Teaching.

The third phase comprises the administration of the research tools in the targeted sample of prospective secondary school science teachers doing the final semester of the B.Ed programme. The collected data were subjected to quantitative analysis using descriptive and inferential statistical techniques in the fourth phase.

Tools Used for the Study

For any research to be successful and worthy, along with suitable procedures, proper data analysis, interpretation and appropriate research instruments are essential.

It is imperative that the instruments employed have to be appropriate, reliable, valid and suitable for the purpose and apt for the selected sample.

The tools used in this study are as follows.

1. Pedagogical Content Knowledge Test
2. Curricular Experiences Rating Scale
3. Scale on Motivational Factors in Science Teaching

The development of each tool is described in the following section. The general pattern of tool description is : a) planning, b) preparation, c) tryout and d) finalisation. All tools used were prepared by the investigator with the help of the supervising teacher.

1. Pedagogical Content Knowledge (PCK) Test

The primary objective of the study is to determine the factors related to the teacher education programme that affect the student teachers' pedagogical content knowledge. The nature of PCK itself is very tacit, and hence the preparation of a comprehensive tool was essential to measure the construct effectively. The researcher finalised a paper-pencil test named Pedagogical Content Knowledge Test with multiple-choice test items for measuring the PCK of prospective secondary school teachers.

Planning

The review of literature on Pedagogical Content Knowledge (PCK) helped put insight into the construct. Investigator aimed at designing a tool that can be used to measure Pedagogical Content Knowledge (PCK) related to the secondary school

Physics curriculum, especially Mechanics. The three different facets of Pedagogic Content Knowledge viz; Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK) were given due weightage.

It was decided to assess pedagogical content knowledge reflective of students' thinking, learning, and misconceptions through multiple-choice questions. The primary task that was performed to make the tool more comprehensive was to analyse the physics curriculum followed in secondary schools of Kerala. Content analysis of both CBSE and state curricula helped the researcher identify that topics related to mechanics were prevalent from class VIII to XII in the secondary school physics curriculum. Content analysis by the researcher in consultation with expert teachers and teacher educators helped in confirming the importance of topics related to Mechanics in the secondary school Physics curriculum and its role in helping students pursue higher-level Physics education successfully. The area for the test was selected considering that the PCK of a teacher should not be assessed considering only a small portion of the content area. Here the researcher has tried to include items from most of the topics related to Mechanics from the secondary school curriculum. Items from all topics related to Mechanics from the secondary school curriculum were included in the development of the PCK Test to ensure comprehensiveness. The tool will also collect the preliminary details of the respondent like the name of the institution, gender, qualification and level of physics studied.

Preparation

After the planning stage, the construction of the tool went through the following steps: confirming the characteristics of the test items fitting the topic-specific PCK, development of test items, the judgment of items, construction of the test, piloting and validation of the instrument. The test is mainly focused on three dimensions of PCK viz., Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK).

In order to measure the three dimensions, the development of test items involved the strategic blending of various teacher related tasks, namely: general pedagogical knowledge**,** organizing concepts into main and subordinate ideas**,** sequencing of ideas and knowledge of misconceptions**,** an adaptation of representations and making suggestions for teaching strategies for specific cases. Test items were designed and included in such a manner that answering the test item requires abilities like respondent's orientation towards teaching, knowledge of the Physics curriculum, knowledge of student ideas(misconceptions), knowledge of effective instructional strategies and knowledge of assessment methods. The blending of all these teacher related tasks into a multiple-choice test format in order to check the Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK) were done. As mentioned in the planning phase, the content area selected for the test was Mechanics from the secondary school physics curriculum.

The sample test items included in the draft of the PCK test are given below.

Pedagogical Knowledge

Which of the following points should a teacher consider while preparing an assessment that supports the personalisation of learning?

i. Plan a common date, time and method of the assessment

ii. Involve students in decision making about assessment and practice,

iii. Provide a range of assessment to ensure inclusivity

a. only(i)and(ii)

b. only (ii) and (iii)

c. only (i) and (iii)

d. (i), (ii) and (iii)

Content Knowledge

You lift a suitcase from the floor and keep it on a table. The work done by you on the suitcase does not depend on

i. Path taken by the suitcase

ii. Time taken by you doing so.

iii. Weight of the suitcase.

iv. Your weight.

a. i & ii

b. ii & iii

c. i & iv

d. iv

Contextual Knowledge

While teaching length measurement in a class for the first time, the teacher asks students to use an eraser and a pencil to measure the length and breadth of the notebook. What would have made the teacher choose pencil and eraser rather than directly using a ruler/scale for measurement?

i. To make students aware of the need and advantages of standard units

ii. To understand what measurement means

iii. To enable to choose the most appropriate object or unit to measure the length

iv. To keep students engaged in class and motivate them to learn.

a. Only i & ii

b. i, ii & iii

c. iii & iv

d. only iv

Out of the 100 items constructed in the initial stage under Pedagogical Knowledge, Content Knowledge and Contextual knowledge, 70 items were finalised by consultation with subject experts and physical science teacher educators. Of the 70 items, 23 items are based on Pedagogical Knowledge, 23 items are based on Content Knowledge, and 24 items are related to Contextual Knowledge. The details of the number of items based on dimensions are given in Table 1.

Table 1

Dimensions and Number of Items of PCK Test (Draft)

Dimensions	Number of items
Pedagogical Knowledge	23
Content Knowledge	23
Contextual Knowledge	24
Total	70

Scoring

All the Pedagogical Content Knowledge Test items had four different options viz; a, b, c and d. The respondent had to put a tick mark on the response sheet against the correct option. The correct answers were given a score of one, and incorrect responses were given zero score. The responses having multiple answers for a single item and items left unanswered were also given zero score.

Try Out

Item analysis of all the 70 items was carried out after administering the test on the sample of 370 prospective secondary school teachers in Kerala. The 370 response sheets obtained were scored, and the total score for each sheet was calculated. Then these were arranged in ascending order of the total score, and the highest and lowest 27 per cent of the 370 sheets (100 sheets) were separated. The discriminating power and difficulty index for each item was calculated. Data and results of item analysis of Pedagogical Content Knowledge Test are given in Table 2.

Table 2

Data and Results of Item Analysis of PCK Test

Item Number (in draft test)	L	U	DI	DP	Item Number (in final test)
1	20	40	0.20	0.30	1
2	20	48	0.28	0.34	2
3	55	58	0.03	0.57	-
4	18	40	0.22	0.29	3
5	23	45	0.22	0.34	4
6	50	58	0.08	0.54	-
7	38	42	0.04	0.40	-

Item Number (in draft test)	L	U	DI	DP	Item Number (in final test)
8	10	48	0.38	0.29	5
9	13	61	0.48	0.37	6
10	16	42	0.26	0.29	7
11	15	45	0.33	0.33	8
12	64	63	-0.01	0.64	-
13	64	63	-0.01	0.64	-
14	25	60	0.35	0.43	9
15	46	71	0.25	0.59	10
16	34	55	0.21	0.45	11
17	64	74	0.10	0.69	-
18	14	40	0.26	0.27	12
19	63	83	0.22	0.73	13
20	52	71	0.12	0.62	-
21	16	71	0.55	0.44	14
22	12	62	0.52	0.37	15
23	17	53	0.36	0.35	16
24	11	46	0.35	0.29	17
25	9	68	0.59	0.39	18
26	14	49	0.35	0.32	19
27	41	41	0	0.41	-
28	22	58	0.36	0.41	20
29	11	39	0.28	0.25	21
30	21	30	0.09	0.26	-
31	16	53	0.37	0.35	22
32	36	55	0.19	0.46	-
33	43	70	0.27	0.57	23
34	14	73	0.59	0.44	24
35	18	44	0.26	0.31	25
36	32	57	0.25	0.45	26
37	50	68	0.18	0.59	-
38	23	45	0.22	0.34	27
39	25	78	0.53	0.52	28
40	17	52	0.35	0.35	29
41	61	69	0.08	0.65	-
42	52	57	0.05	0.55	-
43	27	81	0.54	0.54	30
44	17	53	0.36	0.35	31
45	54	57	0.03	0.56	-

Item Number (in draft test)	L	U	DI	DP	Item Number (in final test)
46	23	68	0.45	0.46	32
47	51	50	-0.01	0.51	-
48	35	63	0.28	0.49	33
49	65	40	-0.25	0.53	-
50	32	44	0.12	0.38	-
51	53	60	0.07	0.57	-
52	35	75	0.42	0.55	34
53	22	67	0.45	0.45	35
54	24	67	0.43	0.46	36
55	39	73	0.34	0.56	37
56	52	60	0.08	0.56	-
57	38	63	0.25	0.51	38
58	46	64	0.18	0.55	-
59	50	62	0.12	0.56	-
60	46	78	0.32	0.62	39
61	48	63	0.15	0.56	-
62	26	53	0.27	0.42	40
63	30	71	0.41	0.51	41
64	33	54	0.21	0.44	42
65	59	66	0.07	0.63	-
66	54	54	0	0.54	-
67	27	51	0.24	0.39	43
68	40	72	0.32	0.56	44
69	25	46	0.21	0.36	45
70	47	76	0.29	0.62	46

The items having a discriminative value greater than 0.20 (Table 2) were accepted, and all the items having less than 0.20 value were rejected (Ebel & Frisbie, 1991). Since the test constructed was topic-specific and confined to specific content area Mechanics, the researcher did not consider difficulty index as primary. Items with discriminative power greater than 0.20 and difficulty index between 0.25 to 0.80 are considered for the final test.

Finalisation

After the item analysis, Pedagogical Content Knowledge Test was finalised with 46 items. The finalised test has 16, 18 and 12 items for measuring Pedagogical Knowledge, Content Knowledge and Contextual Knowledge respectively. Table 3 shows the distribution of the number of items and dimensions of finalised pedagogical Content Knowledge Test.

Table 3

Dimensions and Number of Items of PCK Test

Dimensions	Number of items
Pedagogical Knowledge	16
Content knowledge	18
Contextual Knowledge	12
Total	46

The Pedagogical Content Knowledge Test (Draft and Final) copy along with scoring key and response sheet are given as Appendix A & B respectively.

Reliability

The reliability of a test is its ability to yield consistent results from one set of measures to another. According to Best and Kahn (2006), "Reliability is the degree of consistency that an instrument on procedure demonstrates; whatever it measures, it does so consistently".

The reliability of the Pedagogical Content Knowledge Test was checked using the split-half method. Spearman-Brown coefficient of correlation obtained was .89

which means the test is reliable for measuring PCK in Physics among prospective secondary school teachers.

Validity

An index of validity shows the degree to which a test measures what it intends to measure when compared with the accepted criterion. Best and Kahn (2016) define validity as the quality of a data-gathering instrument or procedure that ensures to measure what is supposed to measure.

The validity of the test was ensured by using both face validity and content validity. A test is said to have face validity when measuring whatever the author has in mind, namely what he thought he was measuring (Garrett,1993). The opinion and suggestions from the experts (Four experienced secondary school Physics teachers and Physical science teacher educators) consulted helped in ensuring the strength of the 46 items. The test items are well screened and scrutinised for their appropriateness based on the test's objectives to ensure face validity.

Content validity refers to the extent to which the items on a test are fairly representative of the entire domain that the test seeks to measure. Content validity of the test was ensured through the careful examination of the topics related to Mechanics from the high school Physics curriculum and preparing items based on each minor concept in Mechanics. The experts' opinions and suggestions on every item were taken, and necessary modification was made in consultation with the guide.

2. Curricular Experiences Rating Scale

Teaching is multiple skill-oriented tasks, and hence teacher education programmes in a short time have to mould fresh graduates without any prior teaching experience into better teachers. Transforming individuals and equipping them with teaching skills and competencies are achieved by providing versatile curricular experiences that every candidate enrolled for the programme has to complete successfully. The opportunities and experiences that every student teacher gets from the institution during the teacher preparation are significant in making a teacher. This scale is used to measure how frequently the student-teacher participates in various curricular experiences during the teacher preparation period (B.Ed).

Planning

The two-year B.Ed curriculum in practice in different universities of Kerala was subjected to analysis. Learning objectives, tasks, assignments, field practices, school internship, and the role of mentor teachers were premier in developing pedagogical skills in student teachers. Based on the literature review and discussions with academicians, experienced teachers and teacher educators, the investigator categorised the learning experience and opportunities that a student-teacher gets in a teacher education institution. Since the tool is aimed at finding the student-teacher pedagogical competencies, it has to address all actions and scenarios a student-teacher goes through while in a teacher preparation programme. The curricular experiences of the student teachers were measured using six variables, viz.,

i. Pre-Internship Learner Engagement

ii. Opportunity to Achieve Learning Objectives

iii. Opportunity to Learn skills

iv. Engagement during School Internship

v. Accomplishments during School Internship

vi. Role of Teacher Educator.

It is also planned to develop the tool on a five-point Likert scale.

Preparation

Based on the literature review, the researcher developed the 'Curricular Experiences Rating Scale' by taking Pre-Internship Learner Engagement, Opportunity to Achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship and Role of Teacher Educator as component variables. They are explained below.

i. ***Pre-Internship Learner Engagement.*** Pre-Internship Learner Engagement means all possible actions that a student-teacher will have to do in the classroom as part of the teacher education programme. The activities meant for preparatory to teaching, fostering teaching, and transforming teaching are considered under this dimension. Preparatory to teaching and fostering teaching include the activities and experiences that they gather from the institution as novice teachers which makes them get ready with teaching. Transforming teaching includes the extended activities and works which go beyond the existing teaching learning process to boost up their gained knowledge. The experience that they gain through these works will help them to adapt to the school environment quickly. Even though all teacher preparation programmes have these activities, student teachers' participation in these activities varies individually. Fourteen items were included in the scale. Table 4 shows the category-wise distribution of items under Pre-Internship Learner Engagement.

Table 4

Category Wise Distribution of Items Under Pre-Internship Learner Engagement.

Categories	Number of items
Preparatory to teaching	5
Fostering teaching	5
Transforming teaching	4
Total Items	14

Examples of items from each category are given below.

Category	Items
Preparatory to teaching	*How frequently you-* ● Listen to lectures ● Make teaching aids and models. ● Participate in group works
Fostering Teaching	● Ask doubts and questions during class. ● Participate in whole-class discussions and debates
Transforming Teaching	● Discuss novel ideas in Physics teaching ● Do a project on science education and its challenges. ● Read about research works in science teaching and science education.

ii. ***Opportunity to Achieve Learning Objectives.*** This section of the tool is meant to understand how frequently the student-teacher, during the teacher education programme, got opportunities to be involved in activities in order to attain key learning objectives related to the B.Ed curriculum. The learning objectives were classified into four categories viz; objectives related to planning and preparation for teaching science lessons, how to use meaningful evaluation in teaching-learning, developing and designing appropriate learning experiences and creating constructivist classrooms. Twenty-six items were included in the scale. Table 5 shows the category-wise distribution of items under participation in Opportunity to Achieve Learning Objectives.

Table 5

Category Wise Distribution of Items Under Opportunity to Achieve Learning Objectives

Categories	Number of items
Planning and preparation for teaching science	7
Use of meaningful evaluation	5
Designing learning experience	7
Creating a constructivist classroom	7
Total	26

Examples of items from each category are given below.

Category	Items
	How frequently do you get opportunities-
Planning and preparation for teaching science	• To practice the different skills of teaching with peers • To analyse the lessons based on the national and state curriculum framework
Use of meaningful evaluation	• To reflect on the lessons taken by self and peers • To use assessment as a means to strengthen learning rather than just grading
Designing learning experience	• To take a lesson on a new topic in class • To develop puzzles, stories and learning activities to motivate students to learn topics.

Category	Items
Creating a constructivist classroom	• To construct learning aids, models and charts to strengthen learning in students • To accommodate a wide range of skills in a lesson • To create specific learning experiences for students. • To discuss learning objectives and learning outcomes of lessons.

iii. ***Opportunity to Learn Skills.*** This section of the tool is meant to understand how frequently the student-teacher, during the teacher education programme, got opportunities to acquire general teaching abilities/skills required for a diverse and inclusive classroom. This includes the opportunity to learn about handling exceptional children, to engage with expert and experienced teachers, to understand existing school practices, standards and values.

The items under the variable fall under two categories viz; understanding the learner and self and professional aspects. Understanding learner and self includes skills related to special strategies for exceptional children, handling diverse cultural backgrounds of learners, and developing standards and values through the appropriate reflection of self-practice to promote the self-esteem of learners. Professional aspects are mainly related to professionalism and improving knowledge and practice in teaching. This section has 13 items. Table 6 shows the category-wise distribution of items under Opportunity to Learn Skills.

Table 6

Category Wise Distribution of Items Under Opportunity to Learn Skills

Categories	Number of items
Understanding the learner and self	8
Professional aspects	5
Total Items	13

Examples of items from each category are given below.

Category	Items
	How frequently you got opportunities to learn-
Understanding the learner and self	• Cater for the diverse cultural background of students in a class. • To engage and teach students from poor socio-economic backgrounds.
Professional aspects	• To understand and practice ethical standards and code of conduct for teachers • To research problems faced by teachers in the teaching-learning process

iv. ***Engagement during School Internship.*** This section of the tool is meant to understand how frequently the student-teacher, during the school internship, got opportunities for task fulfilment. Engagement during School Internship is the extent to which the prospective teachers could complete all the prescribed tasks they had to complete as part of their school internship. These include how often they could follow and observe methods and theories they have learned from their institution, conducting constructivist lessons, effective lesson planning, reflecting on lessons for improvement, and other mandatory engagements during the school internship. Total of nine items were included in this section.

Examples of items are given below.

- Follow and observe the methods and theories I studied in my institution.
- Practice the teaching as I learned during my B.Ed course
- Complete all tasks during the lessons as learned in the B.Ed course.

v. ***Accomplishments during School Internship.*** It is the extent up to which the prospective teachers could successfully perform themselves during school internship. It includes the relationship with the mentor and successful integration of theory and practice during the internship period. Total nine items were included in this section. Examples of items are given below.

- Fulfil the mentor's expectations during the school internship.
- Demonstrate to mentor in school that I could teach according to lesson plan
- Follow the method of teaching studied and planned from college during the school internship.

vi. ***Role of Teacher Educator.*** This section of the scale is meant to understand the student perception of the role of the teacher educator and their competency in motivating and supporting student teachers during the teacher education programme. The items in the scale were created based on the possible actions a teacher educator undertakes while in the classroom. A total of nine items was included in this section.

Examples of items are given below.

- Use evaluation in the most suitable way to give feedback to trainees
- Make trainees aware of the latest research in the area of teaching.
- Good at using and handling ICT and other technologies in the classroom.

Scoring

A five-point Likert type scale was used to measure the extent of curricular experiences a teacher trainee gained during their B.Ed. The five options are *often, intermittently, occasionally, rarely* and *never,* which were scored as 5,4,3,2, and 1 respectively. For every statement, the response of the respondent has to *be 'often*' if they have done the mentioned works frequently all along the course; *'intermittently*' when student teachers' involvement in works mentioned were not that frequent; *'occasionally*' when the frequency of involvement or participation is occasional; '*rarely*' when the frequency of involvement of student-teacher in the mentioned tasks was minimal and '*never*' when the student-teacher never engaged with the works mentioned in the scale.

Tryout

Curricular Experiences Rating Scale was subjected to tryout. The tool was administered to 370 prospective secondary school teachers. Item analysis was performed using the conventional procedure advocated by Edwards (1957) for Likert type statements. The data and result for each item is given in Table 7.

Table 7

Data and Result of Item Analysis of Curricular Experiences Rating Scale

Dimensions	Item Number (in draft scale)	$\bar{X}_1$	$\bar{X}_2$	S1	S2	t
Pre-Internship Learner Engagement	1	4.25	2.35	0.70	0.93	16.29
	2	4.34	2.07	1.31	1.02	18.2
	3	4.33	2.42	1.27	1.10	13.92
	4	4.43	2.65	1.15	0.93	15.94
	5	4.37	2.49	1.15	0.94	15.5
	6	4.53	2.33	1.17	0.81	21.69
	7	4.42	2.43	1.17	0.94	16.84
	8	4.53	2.32	1.25	0.81	22.04
	9	4.45	2.45	1.15	0.86	18.59
	10	4.31	2.44	1.13	0.94	16.89
	11	4.43	2.18	1.24	0.92	19.92
	12	4.15	2.24	1.25	0.98	14.92
	13	4.33	2.46	1.19	0.82	17.28
	14	4.37	2.66	1.12	0.95	15.4
Opportunity to Achieve Learning Objectives	15	4.54	2.64	0.59	1.05	15.76
	16	4.45	2.92	0.64	1.19	11.28
	17	4.56	2.6	0.59	1.02	16.56
	18	4.42	2.79	0.67	1.23	11.62
	19	4.52	2.6	0.56	1.27	13.82
	20	4.54	2.82	0.58	1.01	14.92
	21	4.66	2.69	0.54	1.02	17.2
	22	4.47	2.79	0.74	1.04	13.24
	23	4.71	2.82	0.50	1.18	14.71
	24	4.56	2.68	0.56	1.09	15.36
	25	4.54	2.82	0.52	1.09	14.28
	26	4.47	2.56	0.66	1.17	14.18
	27	4.68	2.8	0.47	1.03	16.55
	28	4.67	2.67	0.57	1.03	17.05
	29	4.65	2.73	0.56	0.89	18.34
	30	4.65	2.69	0.58	1.04	16.47
	31	4.7	2.65	0.51	1.12	16.67
	32	4.43	2.74	0.70	1.13	12.68
	33	4.64	2.64	0.58	1.09	16.24
	34	4.57	2.94	0.59	1.06	13.42

Dimensions	Item Number (in draft scale)	$\bar{X}_1$	$\bar{X}_2$	S1	S2	t
	35	4.48	2.69	0.64	1.00	15.03
	36	4.63	2.91	0.55	1.09	14.09
	37	4.68	2.77	0.49	0.99	17.24
	38	4.48	2.74	0.73	0.99	14.13
	39	4.56	2.85	0.56	1.00	14.96
	40	4.55	2.75	0.59	0.98	15.74
Opportunity to Learn skills	41	4.55	2.63	0.61	1.13	14.96
	42	4.48	2.72	0.52	1.19	13.57
	43	4.55	2.61	0.61	1.12	15.14
	44	4.45	2.54	0.62	1.12	14.86
	45	4.61	2.51	0.51	0.86	21.02
	46	4.6	2.69	0.57	0.99	16.84
	47	4.71	2.47	0.50	0.87	22.34
	48	4.61	2.64	0.55	1.04	16.76
	49	4.59	2.55	0.57	0.93	19.27
	50	4.53	2.6	0.58	1.03	16.29
	51	4.63	2.53	0.49	0.87	21.08
	52	4.42	2.36	0.65	1.32	14.03
	53	4.52	2.85	0.59	0.96	14.82
Engagement during School Internship	54	4.47	2.69	0.63	0.98	15.17
	55	4.62	2.56	0.51	0.87	20.48
	56	4.38	2.81	0.56	1.01	13.55
	57	4.59	2.58	0.59	0.81	20.15
	58	4.57	2.67	0.62	0.82	18.48
	59	4.52	2.57	0.61	0.93	17.18
	60	4.26	2.55	1.02	1.31	10.32
	61	4.6	2.54	0.57	0.76	21.75
	62	4.52	2.37	0.59	0.75	22.52
Accomplishments during School Internship	63	4.57	2.73	0.50	0.80	18.66
	64	4.75	2.43	0.48	0.89	18.28
	65	4.57	2.57	0.58	0.88	12.62
	66	4.67	2.56	0.56	1.08	15.33
	67	4.72	2.84	0.64	1.02	12.43
	68	4.65	2.56	0.51	0.84	12.78
	69	4.64	2.77	0.56	0.93	10.44
	70	4.56	2.53	0.58	0.89	12.36
	71	4.43	2.74	0.58	0.79	9.66

Dimensions	Item Number (in draft scale)	$\bar{X}_1$	$\bar{X}_2$	S1	S2	t
Role of Teacher Educator	72	4.65	2.57	0.70	0.93	22.16
	73	4.67	2.57	1.31	1.02	20.83
	74	4.54	2.45	1.27	1.10	19.86
	75	4.52	2.69	1.15	0.93	15.05
	76	4.53	2.59	1.15	0.94	16.02
	77	4.63	2.67	1.17	0.81	19.96
	78	4.55	2.55	1.17	0.94	18.05
	79	4.5	2.72	1.25	0.81	16.8
	80	4.55	2.49	1.15	0.86	21.17

Finalisation

All the 80 items under five dimensions in the draft scale had a t value greater than 2.58. Hence all items were included in the final scale. Table 8 shows the dimension-wise distribution of the Curricular Experiences Rating Scale (final). Copy of the scale is given as Appendix C.

Table 8

Dimension-wise Distribution of Curricular Experiences Rating Scale (Final)

Dimensions	Number of items
Pre-Internship Learner Engagement	14
Opportunity to Achieve Learning Objectives	26
Opportunity to Learn Skills	13
Engagement during School Internship	9
Accomplishments during School Internship	9
Role of Teacher Educator	9
Total items	80

Reliability

The reliability of a test is its ability to yield consistent results from one set measure to another. Reliability is the degree of consistency that an instrument or procedure demonstrates (Best & Kahn, 2006).

The reliability of the scale was established by means of the test-retest method. The scale was administered to a group of 30 physical science B.Ed. students and again repeated in the same group by giving an interval of two weeks. The scores obtained for the first test were correlated with scores of the retest. The reliability coefficient is found to be .74, which indicates scale is reliable for measuring the quality of curricular experiences of prospective teachers.

Validity

The scale's validity was ensured by establishing face validity and content validity. To ensure face validity, the investigator consulted experts during the scale development, and it was given to experts for the approval of items. They were asked to judge the worth and relevance of the items included in the scale. The experts approved the scale as an appropriate tool for measuring the quality of curricular experiences of prospective teachers.

For ensuring content validity, an adequate number of items were included in each dimension of curricular experiences related to teacher education programmes. Moreover, the scale was given to experts, and they were asked to judge whether the items grouped under each dimension were appropriate. The experts approved the appropriateness of the scale to measure the quality of curricular experiences. Thus, content validity was ensured.

3. Scale on Motivational Factors in Science Teaching.

The success of every learning endeavour depends on psychological support and motivation from within and outside. The making of a teacher as a whole is very complex, and hence the role of attitude, self-efficacy and teacher motivation during the teacher education programme will have a comprehensive impact on the student teachers. The Scale on Motivational factors in Science Teaching aims to collect data from the student teachers related to Attitude towards Science, Self-efficacy and Teacher Motivation. A detailed description of the tool is given below.

Planning

Scales on Motivational Factors in Science Teaching deal with the psychological aspects of student teachers that influence their pedagogical competence. Student teachers' Attitude towards Science, Self-efficacy in teaching Physics and Teacher Motivation are the three main variables included in this tool. Hence this tool has three subscales. The three subscales are

i. Scale of Attitude towards Science
ii. Scale of Self-efficacy
iii. Scale of Teacher Motivation

It is decided to develop a Likert type five-point scale. The statements were planned to frame with five responses viz; strongly agree, agree, do not know, disagree and strongly disagree. The total score corresponding to each variable was used to measure the student teachers' scores of Attitude towards Science, Self-efficacy and the Teacher educator motivation. The preparation of subscales is given separately.

Preparation

i. Scale of Attitude towards Science. Attitude towards science is the positive or negative opinions that individuals have about science, based on their perceptions of science. In this tool, the researcher focused on five dimensions regarding Attitude towards Science viz; student teacher's perception of science, attitude towards the process of science, enjoyment in engaging with science, interest in science, and time spent on science topics. The statements in the tool were framed in a Likert type five-point scale, having responses ranging from strongly disagree to strongly agree. Both positive and negative items were included in the tool. The Scale of Attitude towards Science consisted of 26 items. Out of which, ten are positive and 16 are negative. Table 9 shows dimension wise distribution of the Scale of Attitude towards Science.

Table 9

Dimension Wise Distribution of Items in Scale of Attitude Towards Science

Dimensions	Number of items
Student teacher's perception of science	4
Attitude towards the process of science	11
Enjoyment in engaging with science	5
Interest in science	3
Time spends on science topics	3
Total	26

Examples of items for each dimension are given below.

- Every phenomenon in science happens on its own.

- Science in schools should be given more weightage in terms of time.
- I like to do new experiments that I read in journals and magazines.
- I love and enjoy science lessons.
- I like to spend more time engaging with science-related processes.

ii. ***Self-Efficacy Scale.*** Self-efficacy makes a difference in how people feel, think and act. It is people's judgment of their ability to organise and perform or execute their actions. In the context of the study self-efficacy of prospective teachers is concerned with student teachers' experience, which contributes to further judgements and information on what he/she can do based on their personal experiences in teaching-learning Physics. In this tool, the researcher focuses on five dimensions of Self-efficacy, viz; Instructional planning, Transaction ability, Classroom management and Professional competence. The statements in the tool were framed in a Likert type five-point scale, having responses ranging from strongly agree to strongly disagree. Out of the 16 items, six items are related to Instructional planning, four are related to Transaction ability, and three each to Classroom management and Professional competence. The dimension wise distribution of items is given in Table 10.

Table 10

Dimension Wise Distribution of Self-Efficacy Scale.

	Dimension	Number of items
Self-efficacy	Instructional planning	6
	Transaction ability	4
	Classroom management	3
	Professional competence	3
Total		16

Sample items are given below.

As a student teacher-

- I can design suitable learning activities for learners for all topics to attain learning goals.
- I can integrate ICT in Physics lessons to promote learning.
- I can motivate and handle students having difficulty in learning.
- I am good at collaborating with students smoothly in learning Physics.
- Can incorporate effective classroom management techniques in challenging classroom situations.

iii. Scale of Teacher Motivation. The student teachers are expected to have high intrinsic motivation for pursuing a successful teaching career. Teacher educators, along with the nature of the programme, contribute a significant chunk of extrinsic motivation. Along with the intrinsic motivation, the instructional support, fairness in consideration, individual care, and support given by the teacher educator in fulfiling individual needs make a great deal in drawing out successful teachers. The statements in the tool were framed in a Likert type five-point scale, having responses ranging from strongly agree to strongly disagree. The tool consists of 16 items. Table 11 shows the dimension wise distribution of items in the scale.

Table 11

Dimension Wise Distribution of Items in Scale of Teacher Motivation

Dimensions	Number of items
Instructional support	5
Fairness in consideration	3
Individual care and need fulfilment	8
Total	16

Sample items are given below

- Provide healthy feedback and make aware of my position through timely evaluation
- Give fair consideration to all trainees in the assignment of responsibilities and work.
- Follow the current trends and development in educational research.
- Spend sufficient time on individual student trainees.

Scoring

A five-point Likert scale, with responses varying from, Strongly Agree to Strongly Disagree, was used to measure the Attitude towards Science, Self-efficacy, and Teacher Motivation. In the case of positive statements, the score given for each response was 5, 4, 3, 2 and 1, and for negative statements, it was given vice-versa, respectively.

Try Out

Scale on Motivational Factors in Science Teaching was administered to 370 prospective secondary school teachers in the tryout stage. The responses were scored, and item analysis was performed separately for each subscale using the conventional procedure advocated by Edwards (1957) for Likert type statements. The data and results of item analysis for each item are given in Table 12.

Table 12

Data and Result of Item Analysis of Scale on Motivational Factors in Science Teaching

Dimensions	Item Number (in draft scale)	$\bar{X}_1$	$\bar{X}_2$	S_1	S_2	t
Attitude towards Science	1	4.70	3.16	0.46	1.12	12.75
	2	4.44	2.48	0.62	1.11	15.34
	3	4.78	3.08	0.42	0.95	16.39
	4	4.54	2.95	0.54	1.15	12.52
	5	4.78	2.88	0.42	0.96	18.21
	6	4.72	2.88	0.47	0.90	18.06
	7	4.73	2.61	0.47	1.08	17.99
	8	4.80	3.00	0.43	0.94	17.40
	9	4.74	2.44	0.58	0.97	20.40
	10	4.79	2.76	0.41	0.98	19.19
	11	4.79	2.58	0.41	0.90	22.33
	12	4.78	2.69	0.44	0.96	19.78
	13	4.81	2.97	0.39	0.99	17.28
	14	4.62	2.77	0.56	1.02	15.83
	15	4.86	2.91	0.35	0.95	19.19
	16	4.74	3.77	0.48	0.86	9.80
	17	4.91	4.14	0.29	0.71	10.04
	18	4.83	4.11	0.38	0.71	8.96
	19	4.89	4.00	0.31	0.72	11.27
	20	4.71	3.99	0.48	0.98	6.61
	21	4.73	3.91	0.47	1.16	6.58
	22	4.88	4.02	0.33	0.79	10.05
	23	4.82	3.86	0.39	1.07	8.42
	24	4.80	3.68	0.40	0.99	10.45
	25	4.91	4.06	0.29	0.75	10.59
	26	4.66	4.01	0.50	0.81	6.84

Dimensions	Item Number (in draft scale)	$\bar{X}_1$	$\bar{X}_2$	S_1	S_2	t
Self-efficacy	27	4.62	3.41	0.51	0.77	13.16
	28	4.65	3.60	0.50	0.72	11.93
	29	4.70	3.40	0.46	0.75	14.74
	30	4.79	3.36	0.41	0.81	15.75
	31	4.62	3.41	0.49	0.68	14.42
	32	4.87	3.45	0.34	0.81	16.20
	33	4.48	3.42	0.54	0.82	10.80
	34	4.66	3.58	0.55	0.75	11.53
	35	4.80	3.31	0.40	0.79	16.85
	36	4.72	3.39	0.47	0.95	12.51
	37	4.74	3.39	0.48	0.75	15.11
	38	4.63	3.52	0.49	0.85	11.38
	39	4.73	3.53	0.45	0.88	12.15
	40	4.68	3.53	0.47	0.85	11.89
	41	4.71	3.23	0.46	0.83	15.67
	42	4.63	3.59	0.53	0.67	12.24
Teacher motivation	43	4.62	3.61	0.51	1.00	8.97
	44	4.71	3.77	0.50	0.97	8.61
	45	4.74	3.55	0.46	0.93	11.39
	46	4.68	3.63	0.53	1.08	8.67
	47	4.64	3.79	0.48	0.91	8.24
	48	4.60	3.72	0.51	0.90	8.50
	49	4.64	3.53	0.56	1.08	9.07
	50	4.67	3.59	0.49	1.03	9.41
	51	4.70	3.50	0.50	1.08	10.01
	52	4.54	3.57	0.61	1.06	7.89
	53	4.53	3.71	0.54	0.97	7.34
	54	4.69	3.58	0.51	0.98	10.00
	55	4.59	3.41	0.55	1.07	9.75
	56	4.46	3.40	0.61	1.02	8.86
	57	4.55	3.60	0.56	1.08	7.80
	58	3.79	2.78	1.27	1.40	5.35

Finalisation

All 58 items under three subscales in the draft tool had *t* value greater than 2.58. Hence all items were included in the final scale. Distribution of Items in Scales on Motivational Factors in Science Teaching is given in Table 13, and a copy of the Scale on Motivational Factors in Science Teaching is given in Appendix D.

Table 13

Distribution of Items in Scale on Motivational Factors in Science Teaching

Subscales	Number of items
1. Scale of Attitude Towards Science	26
2. Self-Efficacy Scale	16
3. Scale of Teacher Motivation	16
Total	58

Reliability

The reliability of the scale was established using the test-retest method. The scale was first administered on a sample of 45 prospective secondary school teachers, and a retest was conducted after three weeks. The correlation coefficient between test and retest scores for the three subscales was .79, .86 and .73, respectively. The internal consistency of the scale was also estimated by calculating Cronbach's alpha coefficient and is given in Table 14.

Table 14

Test-Retest Reliability and Cronbach's Alpha Coefficient for Scale on Motivational Factors in Science Teaching

Scale on Motivational Factors in Science Teaching	Test-retest reliability (N=45)	Cronbach's Coefficient Alpha (N=370)
Scale of Attitude Towards Science	.79	.96
Scale of Self-efficacy	.86	.88
Scale of Teacher Motivation	.73	.86

For Likert scale items, Cronbach alpha values ≥ 0.7 and above are acceptable. The reliability values obtained for Scale on Motivational Factors in Science Teaching are high. Hence the scales are reliable

Validity

The validity of the scale was ensured using face validity and content validity. The items in the present scale were phrased least ambiguously, and the meaning of all items was clearly defined. The scale was administered to try out a sample of 30 prospective secondary school teachers. It was found that the subject comprehended the scale clearly and responded to items appropriately. The scale thus possesses face validity.

Content validity refers to the degree to which the test actually measures or is specifically related to the traits for which it was designed. For ensuring content validity, an adequate number of items were included in each dimension of motivational factors in science teaching. Moreover, the scale was given to experts, and they were asked to judge whether the items grouped under each dimension were appropriate. The experts approved the scale's appropriateness to measure the motivational factors in science teaching. Thus, content validity was ensured.

Sample Selected for the Study

The population for the study is the prospective secondary school teachers in Kerala. The student teachers who have completed all the course requirements of a two-year B.Ed programme and a minimum of one month of school internship are taken as samples.

Kretch and Crutchfield (1968) have observed a sample size of 500 would yield reasonably good results, which would keep an error less than five per cent. The investigator decided to have a sample of 700 prospective secondary school teachers for the present study. This sample was drawn from teacher education institutions under all the four universities in Kerala viz; University of Kerala, Mahatma Gandhi University, University of Calicut and Kannur University. The detailed list of institutions from which the sample is drawn is appended as Appendix E. The breakup of the intended sample is given in Table 15.

Table 15

The breakup of the Intended Sample

Female	Male	University of Kerala	M G University	University of Calicut	Kannur University
500	200	200	200	200	100
Total = 700					

Data Collection Procedure, Scoring and Consolidation of Data

After the finalisation of the sample, copies of test booklets and response sheets for the test were prepared. As per the schedule, the investigator visited institutions and cooperated with the teacher in charge of the physical science classroom.

Initially, all necessary instructions regarding multiple tools were given to respondents. In the case of the PCK test, the time limit was strictly observed. No time limit was enforced for completing Curricular Experiences Rating Scale and Scale on Motivational Factors in Science Teaching. After completion of data filling, both the test booklet and response sheet were collected back.

The responses for each tool were scored based on the scoring procedure. Only response sheets that were completely filled were chosen for finalising the sample. Thus, the size of the final sample is 633. The size of the sub-groups considered for the study is given in Table 16.

Table 16

Break up of Final Sample

Female	Male	University of Kerala	M G University	University of Calicut	Kannur University
535	98	137	225	214	57
Total = 633					

After the scoring, the scores of the PCK test, Curricular Experiences Rating Scale, and Scale of Motivational Factors in Science Teaching were consolidated. The collected data were entered into the computer for statistical analysis.

Statistical Techniques Used for Data Analysis

The following statistical techniques are used in the analysis of data.

As the first data analysis step, the fundamental statistical constants such as mean, median, mode, standard deviation, skewness, and kurtosis were determined. Principal statistical analyses were carried out using SPSS software. Significant statistical analyses employed are described below.

a. Two-tailed test of significance of means for large independent samples.

The critical ratio (t) is calculated using the formula,

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} \qquad \text{(Best \& Kahn, 2006)}$$

where

$\bar{X}_1$ = mean of each item in the first group

$\bar{X}_2$ = mean of each item in the second group

S_1 = Standard deviation of each item in the first group

S_2 = Standard deviation of each item in the second group

N_1 = size of the sample of the first group

N_2 = size of the sample of the second group

b. Pearson Product-Moment Coefficient of Correlation

The coefficient of correlation is calculated from raw scores using the formula,

$$r = \frac{N\sum XY - \sum X \sum Y}{\sqrt{\left[N\sum X^2 - \left(\sum X\right)^2\right]\left[N\sum Y^2 - \left(\sum Y\right)^2\right]}}$$ (Garrett, 1966)

where

ΣX	=	Sum of the X scores
ΣY	=	Sum of the Y scores
ΣX^2	=	Sum of the squared X scores
ΣY^2	=	Sum of the squared Y scores
ΣXY	=	Sum of the products of paired X and Y
N	=	Number of paired scores

The obtained r is interpreted in terms of the following.

i. Test of significance of the correlation by Fisher's t-test (Best & Kahn, 2006).

Test of significance of the correlation by Fisher's t-test is done by using the formula

$$t = (r\sqrt{(N-2)})/\sqrt{(1-r^2\ )}$$

, and it is checked whether the obtained t value exceeds 1.96 or 2.58 at 0.05 level and 0.01 level, respectively, where r is the obtained correlation coefficient in each case.

ii. The Confidence Interval of r. If the r-value obtained is significant at a 0.01 level confidence interval of r is estimated using the formula (r ± 2.50 SEr),

Where the standard error, $SEr = \frac{1-r^2}{\sqrt{N-1}}$, r being the obtained coefficient of correlation. If the r-value obtained is significant at a 0.05 level, r is estimated using the formula (r ± 1.96 SEr). Where, SEr = Standard error of r,

r = the obtained coefficient of correlation

iii. Verbal Interpretation of r (Garett, 1966). The following criteria are used for verbally interpreting the degrees of relationship between the variables.

r from 0.00 to ± 0.20: indifferent or negligible relationship

r from 0.20 to ± 0.40: low or slight relationship

r from 0.40 to ± 0.70: substantial or marked relationship

r from 0.70 to ± 1.00: High or very high relationship

iv. Shared Variance (Fox, 1969)

The formula for computing percentage variance shared between variables is $r^2 \times 100$. The obtained value indicates the percentage of variation of the dependent variable attributed to variation in the dependent variable.

c. The Test of Significance of Difference Between Correlation for Large Independent Samples

The difference between correlations was tested for significance by finding out the critical ratio using the formula.

$$t = \frac{Z_1 - Z_2}{\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}} \qquad \text{(Garrett, 1966)}$$

Z_1 and Z_2 are the Fisher's equivalent of the correlation coefficient r_1 and r_2, respectively; N_1 and N_2 are the sizes of the groups compared. The obtained critical ratio is treated as belonging to normal distribution. When the critical ratio exceeds ± 1.96 or ± 2.58, the correlation coefficient is significant at 0.05 level or 0.01 level.

d. Multiple Regression Analysis

Regression analysis is a statistical technique for estimating the relationship among variables that have reason and result relation. Regression models with one dependent variable and more than one independent variable are called multilinear regression. Regression analysis is performed to determine the correlations between two or more variables having cause-effect relations and make predictions for the topic by using the relation.

Answers are sought in this research to questions such as "are there any relations between dependent and independent variables?", "if there are any relations, what is the power of the relation?" "is it possible to make future-oriented predictions regarding the dependent variable?" and "if certain conditions are controlled, what influences does a special variable or group of variables have over another variable or variables?"

In multivariate regression analysis, an attempt is made to account for the variation of the independent variables in the dependent variable synchronically. The multivariate regression analysis model is formulated as in the following.

$$Y' = b_1 x_1 + b_2 x_2 + \ldots + b_n x_n$$

Y' = dependent variable

X_i = independent variable

b_i = regression coefficient

The assumptions of multivariate regression analysis are normal distribution, linearity, freedom from extreme values and having no multiple ties between independent variables.

ANALYSIS

In this chapter, the investigator tried to find out the solution to research questions regarding the extent of PCK in Physics and factors affecting Pedagogical Content Knowledge in Physics of prospective secondary school teachers. Generally, the prospective secondary school teachers who studied Physics as the main subject may have a greater extent of PCK in Physics than their counterparts who have not studied physics as their main subject. The major research question to be answered was whether the select institutional and learner related factors viz., Pre-Internship Learner Engagement, Opportunities to achieve Learning Objectives, Opportunity to learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Teacher Motivation, Attitude towards Science and Self-efficacy affect prospective secondary school teacher's PCK in Physics. The researcher also tried to find out the best predictors of prospective secondary school teachers' PCK in Physics using linear multiple regression analysis.

The data collected from the sample were analyzed statistically with respect to the objectives of the study. The objectives and hypotheses of the study are restated for easy reference.

Objectives

1. To find out the extent of Pedagogical Content Knowledge (PCK) in Physics among prospective secondary school teachers and their sub-groups based on

   a. Gender, and
   b. Level of Physics studied.

2. To find out the extent of the relationship between each of the institutional and learner related variables and PCK in Physics among prospective secondary school teachers and their sub-groups based on

   a. Gender, and
   b. Level of Physics studied

3. To identify the significant institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and sub-groups based on

   a. Gender, and
   b. Level of Physics studied

4. To develop a regression equation for predicting PCK in Physics among prospective secondary school teachers and their sub-groups with the select institutional and learner related variables.

5. To find out the relative efficiency of the select institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and their relevant sub-groups.

Hypotheses

1. There will be a significant relationship between each of the select variables and PCK in Physics for the total group and sub-groups based on

    a. Gender, and

    b. Level of Physics studied

2. PCK in Physics among prospective secondary school teachers can be significantly predicted from the select set of institutional and learner related variables.

The analysis performed in this study are given under separate headings, viz.,

A. Preliminary Analysis

B. Extent of PCK in Physics among prospective secondary school teachers and their sub-groups

C. Relation of select Institutional and Learner related factors with PCK in Physics

D. Significant predictors of Pedagogical Content Knowledge in Physics among prospective secondary school teachers and their sub-groups

A. Preliminary Analysis

The essential descriptive statistics such as mean, median, mode and standard deviation, which serve as inputs for further inferential analysis of data, were calculated as the first stage of analysis. Also, the assumptions made in the use of the product-moment coefficient of correlation (Guilford, 1978) and regression equation (Garrett, 1979) necessitate that the distribution of the dependent variable should be normal or at least not badly skewed. Hence to understand the nature of the distribution of the variables, skewness and kurtosis were also calculated. The values of mean, median, mode, standard deviation, skewness and kurtosis obtained for the variable Pedagogical Content Knowledge (PCK) in Physics (total and component-wise) are presented in Table 17.

Table 17

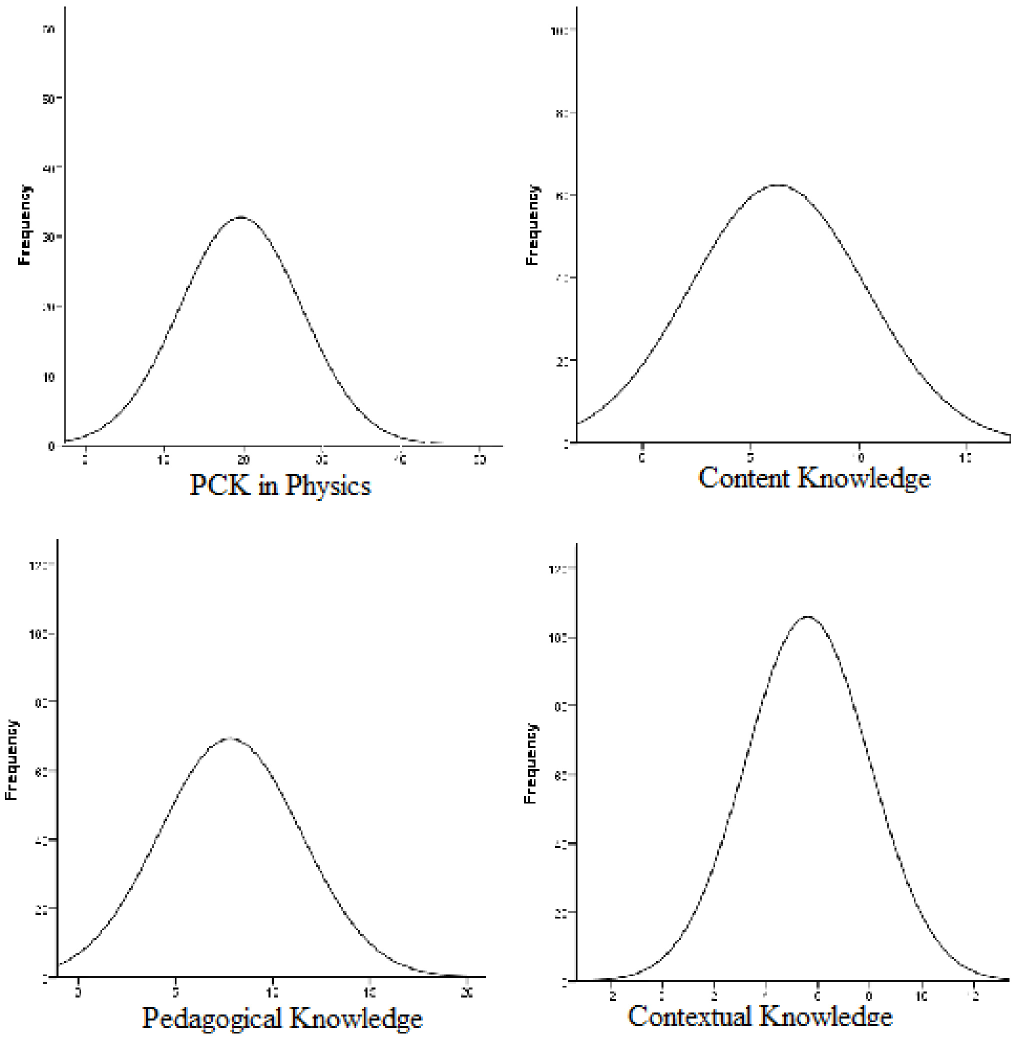
Statistical Constants of Scores of Pedagogical Content Knowledge in Physics (total and component-wise) [N=633]

Variable	Mean	Median	Mode	Standard Deviation	Skewness	Kurtosis
Pedagogical Content Knowledge in Physics	19.67	20.00	21	7.71	0.05	-0.36
Content Knowledge	6.25	5.00	1	4.05	0.45	-.84
Pedagogical Knowledge	7.82	8.00	8	3.64	0.05	-.74
Contextual Knowledge	5.60	5.00	5	2.39	0.11	-.50

Table 17 reveals that the mean, median and mode of the variable PCK in Physics are approximately equal. The z value calculated by dividing skewness (0.05) with its standard error (0.10) is 0.50, which reveals that the distribution of PCK in Physics is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (-0.36) with standard error (0.19) is -1.89. The mean, median and mode of the component Content Knowledge are 6.25, 5 and 1, respectively. The z value calculated by dividing skewness (0.45) by standard error (0.10) is 4.5. The z value calculated by dividing kurtosis (-0.84) with its standard error (0.19) is 4.42. For a sample size greater than 300, a distribution with a kurtosis value up to 7 is considered a normal distribution. Likewise, the mean, median and mode of Pedagogical Knowledge are approximately equal. The z value calculated by dividing skewness (0.05) with its standard error (0.10) is 0.50, revealing that Pedagogical Knowledge's distribution is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (-0.74) by standard error (0.19) is -3.89. The mean, median and mode values are approximately equal for the component Contextual Knowledge. The z value calculated by dividing skewness (0.11) with its standard error (0.10) is 1.10, revealing that the distribution of Contextual Knowledge is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (-0.50) with standard error (0.19) is -1.89, showing the distribution is approximately meso-kurtic. Figure 2 shows the smoothed frequency curve of PCK in Physics (total) and the components Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge.

Figure 2

Smoothed Frequency Curve of PCK in Physics (total and component-wise)



The graphical representations and the statistical indices for the variables viz., Pedagogical Content Knowledge in Physics, Content Knowledge, Pedagogical Knowledge and Contextual Knowledge reveal that they are approximately normal distributions.

As part of the preliminary analysis all the essential descriptive statistics for the select institutional and learner related variables are worked out and is given as Table 18.

Table 18

Statistical Constants of Scores of Select Institutional and learner Related Variables (total and component-wise) (N=633)

Variables	Mean	Median	Mode	Standard Deviation	z value of Skewness	z value of Kurtosis
Pre-Internship Learner Engagement	46.70	43	41	11.16	1.85	-6.29
Opportunity to achieve Learning Objectives	95.73	96	118	19.88	-3.09	-4.18
Opportunity to Learn Skills	47.08	47	36	10.20	-2.57	-4.69
Engagement during School Internship	33.40	35	39	6.76	-5.15	-4.64
Accomplishments during School Internship	34.95	38	40	6.91	-7.72	-3.25
Role of Teacher Educator	34.10	36	40	6.97	-5.97	-3.35
Attitude towards Science	110.78	118	127	3.66	-9.16	-2.27
Self-Efficacy	66.40	69	69	8.37	-11.22	8.04
Teacher Motivation	64.86	66	64	7.84	-7.52	1.96

Table 18 reveals for Pre-Internship Learner Engagement mean (46.70) is greater than median (43) and mode (41). The z value calculated by dividing skewness (0.18) with its standard error (0.097) is 1.85, which reveals that the distribution of Pre-

Internship Learner Engagement is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (-1.22) with standard error (0.19) is -6.29. The mean, median and mode of Opportunity to achieve Learning Objectives are 95.73, 96 and 118, respectively. The z value calculated by dividing skewness (-0.3) by standard error (0.097) is 2.57. The z value calculated by dividing kurtosis (-0.81) with its standard error (0.19) is -4.18. The mean, median and mode of Opportunity to Learn Skills are 47.08, 47 and 36. The z value calculated by dividing skewness (0.25) with its standard error (0.097) is -2.57, reveals that distribution is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (0.91) by standard error (0.19) is -4.69. The mean, median and mode values are approximately equal for the variable Engagement during School Internship. The z value calculated by dividing skewness (0.5) with its standard error (0.097) is -5.15, reveal that the distribution of Engagement during School Internship is not significantly deviated from symmetry. The z value calculated by dividing kurtosis (-0.9) with standard error (0.19) is -4.64, showing the distribution is approximately meso-kurtic. In the case of Accomplishments during School Internship mean, median and mode are 34.95, 38, and 40, respectively. The calculated z value for skewness and kurtosis is -7.72 and -3.25, respectively. The distribution is positively skewed and mesokurtic. The mean, median and mode of role of teacher educator is 34.10, 36, and 40, respectively. The calculated z value for skewness and kurtosis is -5.97 and -3.35, respectively. The distribution is not significantly deviated from normal and is mesokurtic in nature.

The mean, median and mode of Attitude towards Science is 110.78, 118, and 127, respectively. The mode is greater than mean and median. The calculated z value for skewness and kurtosis is -9.16 and -2.27, respectively. The distribution is positively skewed and platykurtic in nature. The mean, median and mode of Self-Efficacy is 66.40, 69, and 69, respectively. The calculated z value for skewness and kurtosis is -11.22 and 8.04, respectively. The distribution is positively skewed and leptokurtic in nature. The mean, median and mode of Teacher Motivation is approximately equal. The calculated z value for skewness and kurtosis is -7.52 and 1.96, respectively. The distribution is positively skewed and leptokurtic in nature.

B. Extent of PCK in Physics Among Prospective Secondary School Teachers and Their Sub-Groups

The extent of Pedagogical Content Knowledge in Physics (total and component-wise) among prospective secondary school teachers for the total sample and relevant sub-groups are found separately by finding mean scores and percentiles.

i. *The extent of PCK in Physics Among Prospective Secondary School Teachers*

The mean scores of PCK in Physics (total and component-wise) are analyzed to find the extent of PCK in Physics in the total sample (N=633). The data and results are given in Table 19.

Table 19

Mean Scores of Pedagogical Content Knowledge in Physics (total and component-wise) Among Prospective Secondary School Teachers

Category	Pedagogical Content Knowledge in Physics			
	PCK in Physics	Content Knowledge	Pedagogical Knowledge	Contextual Knowledge
Mean Scores	19.67	6.25	7.82	5.60

From Table 19, it is found that the mean score of PCK in Physics is 19.67. The maximum possible score of PCK in Physics is 46, and the least possible score is 0. Since the mean score of PCK in Physics obtained by the sample is 19.67, even less than half of the possible maximum score, the extent of PCK in Physics is low for the selected sample. The mean score for Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge are 6.25, 7.82 and 5.60, respectively. The maximum scores for Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge are 18, 16 and 12, respectively. All the mean scores are below half waypoint. Among the mean scores, the mean score of Pedagogical Knowledge is greater than Content Knowledge and Contextual Knowledge. The percentile scores of PCK in Physics (total and component-wise) are given in Table 20.

Table 20

Percentile Scores of Pedagogical Content Knowledge in Physics Among Prospective Secondary School Teachers

	Scores			
Percentile	PCK in Physics	Content Knowledge	Pedagogical Knowledge	Contextual Knowledge
90	31	12	13	9
80	26	10	11	8
70	24	9	10	7
60	21	7	8	6
50	20	5	8	5
40	18	4	7	5
30	16	4	6	4
20	14	2	4	3
10	8	1	3	2

The examination of scores of PCK in Physics on percentile norms given in Table 20 shows that only ten per cent of student teachers have scored greater than 31. Even if the maximum possible score is 46, 50 per cent of student teachers have scored less than 20. Examining the percentile scores of components Content Knowledge (CK), Pedagogical Knowledge (PK) and Contextual Knowledge (CxK), we can see that 50 per cent of student teachers have scored below 5, 8 and 5 when the maximum possible scores are 18, 16 and 12 respectively.

ii. Extent of PCK in Physics in Relevant Sub Groups

The extent of PCK in Physics among relevant sub-groups can be understood from the mean scores of PCK in Physics. The mean score of PCK in Physics among subgroups based on Gender and Level of Physics studied are given in Table 21.

Table 21

Mean Scores of PCK in Physics Among Prospective Secondary School Teachers Based on Relevant Sub-Groups

Dimensions	Mean Scores of PCK in Physics					
	Gender		Level of Physics Studied			
	Male (N=98)	Female (N=535)	BSc Physics (N=151)	MSc Physics (N=171)	Sub. Physics (N=275)	12th level (N=36)
PCK in Physics	24.49	18.79	20.51	21.98	17.88	18.83
Content Knowledge	8.23	5.89	6.35	7.51	5.46	5.89
Pedagogical Knowledge	9.44	7.52	8.16	8.47	7.23	7.83
Contextual Knowledge	6.82	5.37	6.00	6.00	5.19	5.11

Table 21 reveals that the mean scores of PCK in Physics among male and female prospective secondary school teachers are 18.79 and 24.49, respectively. The prospective male secondary school teachers have better PCK in Physics than their female counterparts (t=6.59**). While considering the mean scores of components of PCK in Physics also, the male student teachers have higher scores than their counterparts (t=4.5**, 4.72** & 5.52**) respectively for the components viz., Content knowledge, Pedagogical knowledge and Contextual Knowledge. When analyzing the mean scores of PCK in Physics, the student teachers who have done M. Sc in Physics have a mean score of 21.98 which is higher than the mean scores of all other groups (t value for comparisons between MSc with Physics main & BSc with Physics main, MSc with Physics main & BSc with Physics subsidiary, MSc with

Physics main and Physics studied at 12^{th} level only are 1.76, 5.17** and 3.12** respectively).

Student teachers who have studied Physics as the main subject up to their graduation (BSc Physics) have higher mean scores of PCK in Physics (20.51) than others who have studied it as a subsidiary subject for graduation (17.88) or studied Physics only up to 12^{th} as a subject (18.83). While considering the components of PCK in Physics also, the mean scores of student teachers having graduation or post-graduation in Physics have higher mean scores in Content Knowledge, Pedagogical Knowledge and Contextual Knowledge than the other groups. It can be seen that student teachers who have studied Physics only up to 12^{th} as a subject have a higher mean score in PCK (18.83) than the student teachers who have studied Physics as a subsidiary subject during graduation. The t value for comparisons between B. Sc Physics and sub physics, B. Sc Physics and twelfth level are 3.69 and 1.77 respectively.

While considering the mean scores of components based on the Level of Physics studied, student teachers from all categories have mean scores just up to the halfway point in the case of Pedagogical Knowledge and Contextual Knowledge, where maximum scores are 16 and 12, respectively. The mean scores of Content Knowledge for all categories are less than half of the maximum score (18).

Comments. The results discussed above show that the extent of PCK in Physics (in total and component-wise) among prospective secondary school teachers is meagre. Among the selected sample, the student teachers who have done post-graduation in Physics have comparatively higher PCK in Physics, followed by those who have graduated with Physics as the main subject. The same trend is repeated in the case of components also. Student teachers' mean scores are nearly half of the maximum score or below half for all the three components Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge.

In the subgroups also, PCK in Physics is low. PCK in Physics (total and component-wise) is significantly high in the case of prospective secondary school male teachers compared to their female counterparts. The difference in PCK in Physics between prospective secondary school teachers who have completed their graduation in physics and those who have post-graduation in Physics is not significant. The difference in the component Content Knowledge is significant between them. Prospective secondary school teachers who have done graduation with Physics as the main subject have significantly higher PCK in Physics than those who have studied physics as a subsidiary subject during graduation. Prospective teachers with post-graduation in Physics have significantly higher PCK in Physics than prospective secondary school teachers who have studied Physics as a subsidiary subject for graduation and those who have studied Physics only up to class twelfth.

Since the analysis reveal that the extent of PCK in Physics among prospective male secondary school teachers and post graduates in physics is higher than their counter parts, the researcher also studied the extent of the independent variables in total and subgroups. The results are given in Table 22 and Table 23.

Table 22

Mean Scores of Select Institutional and learner Related Variables Among Prospective Secondary School Teachers (N=633)

	Variables	Mean Scores
Select Institutional and Learner Related Factors	Pre-Internship Learner Engagement (PLE)	46.70
	Opportunity to achieve Learning Objectives (OALO)	95.73
	Opportunity to Learn Skills (OLS)	47.08
	Engagement during School Internship (EDSI)	33.40
	Accomplishments during School Internship (ADSI)	34.95
	Role of Teacher Educator (RTE)	34.10
	Attitude towards Science (ATS)	110.78
	Self-Efficacy (Slf-e)	66.40
	Teacher Motivation (TM)	64.86

From Table 22, it is found that the mean score of Pre-Internship Learner Engagement is 46.70. The maximum possible score of Pre-Internship Learner Engagement is 70, and the least possible score is 0. The mean score of Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy, and Teacher Motivation are 46.70, 95.73, 47.08, 33.40, 34.95, 34.10, 110.78, 66.40 and 5.60, respectively. The maximum scores for Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy, and Teacher Motivation are 70, 130, 65, 45, 45, 45, 130, 80, and 80, respectively.

Table 23

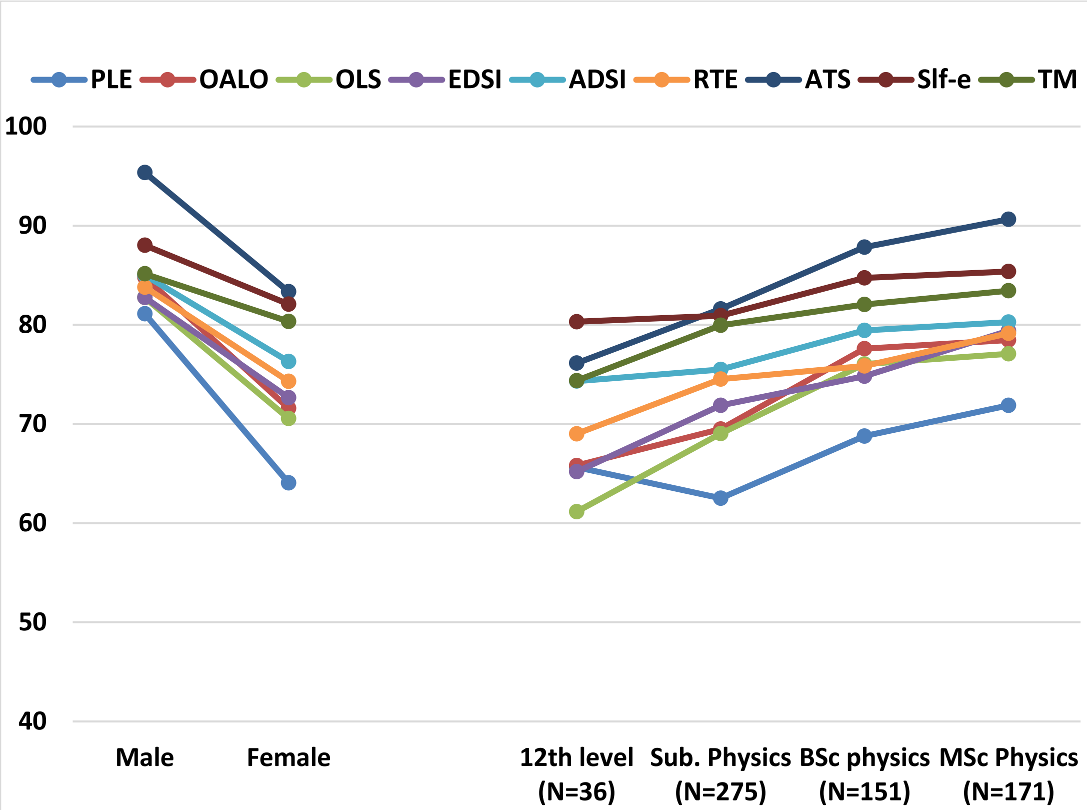
Mean Scores of Select Institutional Learner Related Variables Among Relevant Sub-Groups

Mean Scores of Select Institutional and Learner Related Variables						
	Gender		Level of Physics Studied			
Variables	Male (N=98)	Female (N=535)	BSc Physics (N=151)	MSc Physics (N=171)	Sub. Physics (N=275)	12th level (N=36)
Pre-Internship Learner Engagement	56.79	44.85	48.15	50.30	43.76	45.94
Opportunity to achieve Learning Objectives	110.24	93.08	100.89	101.99	90.34	85.56
Opportunity to Learn Skills	53.79	45.85	49.42	50.10	44.88	39.75
Engagement during School Internship	37.24	32.70	33.66	35.73	32.35	29.33
Accomplishments during School Internship	38.26	34.34	35.74	36.12	33.97	33.44
Role of Teacher Educator	37.71	33.43	34.13	35.61	33.53	31.06
Attitude towards Science	123.97	108.36	114.17	117.83	106.00	98.97
Self-Efficacy	70.42	65.67	67.79	68.30	64.74	64.25
Teacher Motivation	68.11	64.27	65.63	66.75	63.96	59.50

The extent of select independent variables is clearly evident from Figure 3.

Figure 3

Mean Percentage Scores of Select Institutional and Learner Related Variables



C. Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge (PCK) in Physics

Results of the estimation of the relationship of Pedagogical Content Knowledge in Physics with select institutional factors viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator and Teacher motivation and learner related factors viz., Attitude towards Science and Self-Efficacy among prospective secondary school teachers and the sub-groups based on Gender and Level of Physics studied are discussed below.

i. Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge in Physics Among Prospective Secondary School Teachers

The nature and extent of the relation between select institutional and learner related factors with Pedagogical Content Knowledge (PCK) in Physics viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Teacher motivation, Attitude towards Science and Self-Efficacy is estimated using Pearson's product-moment coefficient of correlation. The obtained r is described in terms of size and direction of r, the statistical significance of the coefficient (by Fisher's t-test), confidence interval of r and shared variance.

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics among prospective secondary school teachers are given in Table 24.

Table 24

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics (N = 633)

Variables Compared with PCK in Physics	r	Fisher's t	Confidence Interval	Shared Variance
Pre-Internship Learner Engagement	.305**	8.19	(.20, .41)	9.61
Opportunity to achieve Learning Objectives	.337**	8.99	(.24, .44)	11.36
Opportunity to Learn Skills	.308**	8.13	(.21, .41)	9.49
Engagement during School Internship	.250**	6.49	(.15, .40)	6.25
Accomplishments during School Internship	.199**	5.1	(.10, .30)	3.96
Role of Teacher Educator	.204**	5.23	(.10, .30)	4.16
Attitude towards Science	.396**	10.83	(.32, .46)	15.68
Self-Efficacy	.202**	5.18	(.10, .30)	4.08
Teacher Motivation	.188**	4.81	(.09, .29)	3.53

* Indicates $P \leq 0.01$

Table 24 reveals that the obtained coefficient of correlation for all the variables compared is low but positive and significant at the 0.01 level. The shared variance indicates the per cent of the variance of the dependent variable PCK in Physics accounted for by each independent variable. The shared variance for Pre-Internship Learner Engagement indicates that nearly 10 per cent of the variance in PCK in Physics is accounted for by variance in Pre-Internship Learner Engagement. Population r between these variables varies from .20 to .41. The shared variance for Opportunity to achieve Learning objectives indicates that nearly 11 per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to achieve Learning objectives. Population r between these variables varies from .24 to .44. The shared variance for Opportunity to Learn Skills indicates that nearly nine per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to Learn Skills. Population r between these variables varies from .21 to .41. The shared variance for Engagement during School Internship indicates that nearly 6.25 per cent of the variance in PCK in Physics is accounted for by this variable. Population r between these variables varies from .15 to .40. The shared variance for Accomplishments during School Internship indicates that Accomplishments during School account for nearly four per cent of the variance in PCK in Physics Internship. Population r between these variables varies from .10 to .30. The shared variance for the Role of the Teacher Educator indicates that the Role of the Teacher Educator accounts for nearly four per cent of the variance in PCK in Physics. Population r between these variables varies from .10 to .30. The shared variance (15.68) for Attitude towards Science indicates that nearly 16 per cent of the variance in PCK in Physics is accounted for by Attitude towards Science. Population r between these variables varies from .32 to .46. The shared variance for Self-Efficacy indicates nearly four per cent of the variance in PCK in Physics is accounted for by Self-Efficacy. Population r between these variables varies from .10 to .30. The shared variance of 3.53 for Teacher Motivation indicates that nearly three per cent of the variance in PCK in Physics is accounted for by Teacher Motivation. Population r between these variables varies from .09 to .29.

Discussion. A significant but low positive correlation exists between select institutional and learner related factors and PCK in Physics among prospective secondary school teachers. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills. Teacher Motivation has the most negligible correlation with prospective secondary school teachers' PCK in Physics.

ii. Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge in Physics based on Gender.

Results of the estimation of the relationship of Pedagogical Content Knowledge in Physics with select institutional factors viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator and Teacher Motivation and learner related factors viz., Attitude towards Science and Self-Efficacy based on Gender are discussed below.

The relation between select institutional and learner-related factors with Pedagogical Content Knowledge (PCK) in Physics is estimated using Pearson's product-moment coefficient of correlation. The obtained r is described in terms of size and direction of r, the statistical significance of the coefficient (by Fisher's t-test), confidence interval of r, shared variance and test of significance of the difference between r.

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics for sub-groups based on Gender are given in Table 25.

Table 25

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics based on Gender.

Variable Related with PCK in Physics	Female N = 535				Male N = 98				t
	r	Fisher's t	Confidence Interval	Shared Variance	r	Fisher's t	Confidence Interval	Shared Variance	
Pre-Internship Learner Engagement	.210**	5.4	(.10,.31)	4.41	.320**	8.48	(.08, .55)	10.24	-2.22*
Opportunity to achieve Learning Objectives	.284**	7.44	(.18, .38)	8.07	.239*	6.18	(.14, .44)	5.71	0.93
Opportunity to Learn Skills	.253**	6.57	(.15, .35)	6.4	.246*	6.38	(.05, .45)	6.05	0.37
Engagement during School Internship	.184**	4.7	(.08, .28)	3.39	.288**	7.55	(.06, .52)	8.29	-2.04*
Accomplishments during School Internship	.136**	3.45	(.04, .24)	1.85	.260**	6.76	(.06, .44)	6.76	-2.59**
Role of Teacher Educator	.149**	3.79	(.05,.25)	2.22	0.18	4.66		-	-
Attitude towards Science	.359**	9.66	(.25,.45)	12.89	.269**	7.02	(.03, .49)	7.24	1.67
Self-Efficacy	.162**	4.12	(.06,.26)	2.62	.168**	4.28	(.07, .27)	2.82	-0.11
Teacher Motivation	.158**	4.02	(.06, .26)	2.5	0.09	2.15		-	-

* indicates $P \leq 0.05$
** indicates $P \leq 0.01$

Table 25 reveals that the coefficient of correlation for the variable Pre-Internship Learner Engagement with PCK in Physics is low but positive and significant at 0.01 level for both prospective male and female secondary school teachers. The shared variance indicates the per cent of the variance of the dependent variable PCK in Physics accounted for by each independent variable. The shared variance in the case of prospective male and female secondary school teachers are 10.24 and 4.41, respectively, which means in the case of prospective male secondary school teachers, 10 per cent of the variance of PCK in Physics is attributable to variance in Pre-Internship Learner Engagement. For prospective female teachers, four per cent of the variance of PCK in Physics is attributable to variance in Pre-Internship Learner Engagement. The population r lies in the interval (.8, .55) and (.10, .31) for prospective male and female secondary school teachers. The critical ratio obtained (-2.22) reveals a significant gender difference in the relationship between Pre-Internship Learner Engagement and PCK in Physics. The extent of the relationship is greater among male prospective secondary school teachers.

The correlation coefficient for the variable Opportunity to achieve Learning Objectives is low but positive and significant at 0.01 level for prospective female secondary school teachers and significant only at 0.05 level for prospective male secondary school teachers. The shared variance in the case of male and female prospective secondary school teachers is 5.71 and 8.07, respectively, which means that the Opportunity to achieve Learning Objectives accounts for nearly six per cent of the variance in PCK in Physics among the male group and nearly eight per cent of the variance in PCK in Physics among the female group. The population r lies in the interval (.14, .44) and (.18, .38) for prospective male and female secondary school teachers. The critical ratio obtained (0.93) reveals no significant gender difference in the relationship between the Opportunity to achieve Learning Objectives and PCK in Physics.

The coefficient of correlation for the variable Opportunity to Learn Skills is low but positive and significant at 0.01 level for prospective female secondary school teachers, whereas for prospective male secondary school teachers, it is significant only at 0.05 level. The shared variance in the case of prospective male and female secondary school teachers are 6.05 and 6.40, respectively, which means for both male and female groups, approximately six per cent of the variance of PCK in Physics is attributable to variance in Opportunity to Learn Skills. The population r lies in the interval (.05, .45) and (.15, .35) for prospective male and female secondary school teachers. The critical ratio obtained (0.37) reveals no significant gender difference in the relationship between Opportunity to Learn Skills and PCK in Physics.

The correlation coefficient for the variable Engagement during School Internship is low but positive and significant at 0.01 level for prospective male and female secondary school teachers. The shared variance in the case of male and female prospective secondary school teachers are 8.29 and 3.39, respectively, which means for prospective male and female secondary school teachers, per cent of the variance of PCK in Physics is attributable to variance in Engagement during School Internship is approximately eight and three per cent respectively. The population r lies in the interval .06 to .52 and .08 to .28 for male and female groups. The critical ratio obtained (-2.04) reveals a significant gender difference in the relationship between Engagement during School Internship and PCK in Physics. The extent of the relationship is greater among prospective male secondary school teachers.

The correlation coefficient for the variable Accomplishments during School Internship is low but positive and significant at 0.01 level for prospective male and female secondary school teachers. The shared variance in the case of prospective male and female secondary school teachers are 6.76 and 1.85, respectively, which means that for prospective male and female secondary school teachers, per cent of the variance of PCK in Physics is attributable to variance in Accomplishments during School Internship is approximately seven and two per cent, respectively. The population r lies in the interval (.06, .44) and (.04, .24) for prospective male and female secondary school teachers. The critical ratio obtained (-2.59) reveals a significant gender difference in the relationship between Accomplishments during School Internship and PCK in Physics. The extent of the relationship is greater among prospective male secondary school teachers.

The correlation coefficient for the variable Role of Teacher Educator is low but positive and significant at 0.01 level for prospective female secondary school teachers. In the case of the male group, the relation is negligible and not significant even at a 0.05 level. The shared variance in the case of female prospective secondary school teachers is 2.22, which means two per cent of the variance of PCK in Physics is attributable to variance in the Role of Teacher Educator. The population r lies in the interval (.05, .25).

The correlation coefficient for the variable Attitude towards Science is low but positive and significant at 0.01 level for both male and female prospective secondary school teachers. The shared variance in the case of prospective male and female secondary school teachers is 7.24 and 12.89, respectively, which means that for prospective male and female secondary school teachers, per cent of the variance of PCK in Physics is attributable to variance in Attitude towards Science is approximately seven and 13 per cent, respectively. The population r lies in the interval (.03, .49) and (.25, .45) for male and female groups. The critical ratio obtained (1.67) reveals no significant gender difference in the relationship between Attitude towards Science and PCK in Physics.

The correlation coefficient for the variable Self-Efficacy is low but positive and significant at 0.01 level for prospective male and female secondary school teachers. The shared variance in the case of prospective male and female secondary school teachers is 2.82 and 2.62, respectively, which means approximately three per cent of the variance of PCK in Physics is attributable to variance in Self-Efficacy in both the groups. The population r lies in the interval (.07, .27) and (.06, .26) for male and female groups. The critical ratio obtained (-0.11) reveals no significant gender difference in the relationship between Self-Efficacy and PCK in Physics.

The correlation coefficient for the variable Teacher Motivation is low but positive and significant at 0.01 level for female prospective secondary school teachers. In the case of male prospective secondary school teachers, the relation is negligible and hence not significant even at 0.05 level. The shared variance for female prospective secondary school teachers is 4.02, which means nearly four per cent of the variance of PCK in Physics is attributable to variance in Teacher Motivation. The population r lies in the interval (.06, .26).

The critical ratio obtained for the variables viz., Pre-Internship Learner Engagement, Engagement during School Internship and Accomplishments during School Internship shows a significant gender difference in the extent of the relationship between these variables and PCK in Physics. The relationship between all the three variables and PCK in Physics is higher among male prospective secondary school teachers than their counterparts.

Discussion. A significant and positive correlation exists between select institutional and learner related factors and PCK in Physics in the sub-samples based on Gender. For female prospective secondary school teachers, the highest correlations are found between the variables Attitude towards Science and PCK in Physics, followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills. Accomplishments during School Internship have the most negligible correlation with prospective female secondary school teachers' PCK in Physics. For male prospective secondary school teachers, the highest correlations are found between the variables Pre-Internship Learner Engagement and PCK in Physics, followed by Engagement during School Internship and Attitude towards Science. Correlations of Role of Teacher Educator and Teacher Motivation are negligible with prospective male secondary school teachers' PCK in Physics. There is a significant gender difference in the extent of the relationship between Pre-Internship Learner Engagement, Engagement during School Internship and Accomplishments during School Internship and PCK in Physics. The relationship between the above three variables and PCK in Physics is higher among male prospective secondary school teachers than their counterparts.

iii. Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge in Physics based on Level of Physics Studied.

The relationship of Pedagogical Content Knowledge in Physics with select institutional factors viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator and Teacher Motivation and learner related factors viz., Attitude towards Science and Self-Efficacy for the sub-groups based on the Level of Physics studied are detailed below.

The sample comprises Prospective secondary school teachers who have done graduation with Physics as main subject (BSc Physics), Prospective secondary school teachers who have post-graduation in Physics (MSc Physics), Prospective secondary school teachers who have done graduation with Physics as a subsidiary subject (Sub. Physics) and those who have studied Physics only up to class twelve (Class 12^{th}). Details are given under separate headings.

a) ***Relation of Select Factors with PCK in Physics among Prospective Secondary School Teachers who have done Graduation with Physics as Main Subject (BSc Physics)***

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics among prospective secondary school teachers who have done graduation with Physics as the main subject are given in Table 26.

Table 26

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective Secondary School Teachers who have done Graduation with Physics as Main Subject *(BSc Physics) (N = 151)*

Variables Compared with PCK in Physics	r	Fisher's t	Confidence Interval	Shared Variance
Pre-Internship Learner Engagement	.180*	4.6	(.03, .33)	3.24
Opportunity to achieve Learning Objectives	.280**	7.33	(.08, .48)	7.84
Opportunity to Learn Skills	.194*	4.97	(.04, .24)	3.76
Engagement during School Internship	.229**	5.91	(.03, .43)	5.24
Accomplishments during School Internship	0.036	0.9	-	-
Role of Teacher Educator	0.084	2.12	-	-
Attitude towards Science	.315**	8.34	(.13, .49)	9.92
Self-Efficacy	.236**	6.1	(.04, .44)	5.57
Teacher Motivation	.234**	6.05	(.02, .44)	5.48

* indicates $P \leq 0.05$
** indicates $P \leq 0.01$

Table 26 reveals that the obtained coefficient of correlation for all the variables compared is low but positive and significant at 0.01 level or 0.05 level except for Accomplishments during School Internship and Role of Teacher Educator. The shared variance indicates the per cent of the variance of the dependent variable PCK in Physics accounted for by each independent variable. The shared variance for Pre-Internship Learner Engagement is 3.24, and it shows that Pre-Internship Learner Engagement accounts for 3.24 per cent of the variance in PCK. Population r between these variables varies from .03 to .33. The shared variance (7.84) for Opportunity to achieve Learning Objectives indicates that nearly eight per cent of the variance in PCK in Physics is attributable to Opportunity to achieve Learning objectives. Population r between these variables varies from .08 to .48. The shared variance (3.76) for Opportunity to Learn skills indicates that nearly four per cent of the variance in PCK in Physics is attributable to Opportunity to Learn skills. Population r between these variables varies from .04 to .24. The shared variance (5.24) for Engagement during School Internship indicates that approximately five per cent of the variance in PCK in Physics is attributable to Engagement during School Internship. Population r between these variables varies from .03 to .43. The percentage of variance in PCK explained by variance in Attitude towards Science is about 10 per cent. Population r between these variables varies from .13 to 049. The percentage of variance in PCK explained by variance in Self Efficacy is about six per cent. Population r between these variables varies from .04 to .44. The shared variance of 5.48 for Teacher Motivation indicates that nearly five per cent of the variance in PCK in Physics is attributable to Teacher Motivation. Population r between these variables varies from .02 to .44.

b) *Relation of Select Factors with Pedagogical Content Knowledge in Physics among Prospective Secondary School Teachers who have Post-Graduation in Physics*

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics among Prospective secondary school teachers who have post-graduation in Physics (MSc Physics) are given in Table 27.

Table 27

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective secondary school teachers who have post-graduation in Physics *(M.Sc. Physics) (N = 171)*

Variables Compared with PCK in Physics	r	Fisher's t	Confidence Interval	Shared Variance
Pre-Internship Learner Engagement	.455**	13.01	(.31, .61)	21.16
Opportunity to achieve Learning Objectives	.428**	11.9	(.28, .58)	18.32
Opportunity to Learn Skills	.409**	11.26	(.26, .56)	16.73
Engagement during School Internship	.390**	10.64	(.21, .57)	15.21
Accomplishments during School Internship	.335**	8.93	(.14, .51)	11.22
Role of Teacher Educator	.338**	9.02	(.14, .54)	11.42
Attitude towards Science	.370**	10	(.19, .55)	13.69
Self-Efficacy	.220**	5.67	(.04, .40)	4.84
Teacher Motivation	.143	3.62	-	-

** indicates $P \leq 0.01$

Table 27 reveals that the obtained coefficient of correlation for the variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills are substantial, positive and significant at 0.01 level. The Coefficient of correlation for the variables viz., Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science and Self-Efficacy are low but positive and significant at 0.01 level. The correlation coefficient for the variable Teacher Motivation is insignificant even at a 0.05 level.

The shared variance indicates the per cent of the variance of the dependent variable PCK in Physics accounted for by each independent variable. The shared variance (21.16) for Pre-Internship Learner Engagement indicates that nearly 21 per cent of the variance in PCK in Physics is attributable to Pre-Internship Learner Engagement. Population r between these variables varies from .31 to .61. The shared variance (18.32) for Opportunity to Achieve Learning objectives indicates that nearly 18 per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to Achieve Learning objectives. Population r between these variables varies from .28 to .58. The shared variance (16.73) for Opportunity to Learn skills indicates that approximately 17 per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to Learn Skills. Population r between these variables varies from .26 to .56. The shared variance (15.21) for Engagement during School Internship indicates that approximately 15 per cent of the variance in PCK in Physics is accounted for by variance in Engagement during School Internship. Population r between these variables varies from .21 to .57. The shared variance (11.22) for Accomplishments during School Internship indicates that nearly 11 per cent of the variance in PCK in Physics is accounted for by variance in Accomplishments during School Internship. Population r between these variables varies from .14 to .51. The shared variance (11.42) for Role of Teacher Educator indicates that approximately 11 per cent of the variance in PCK in Physics is accounted for by variance in Role of Teacher Educator. Population r between these variables varies from .14 to .54. The shared variance of 13.69 for Attitude towards Science indicates that approximately 14 per cent of the variance in PCK in Physics is accounted for by variance in Attitude towards Science. Population r between these variables varies from .19 to .55. The shared variance (4.84) for Self-Efficacy indicates that nearly five per cent of the variance in PCK in Physics is accounted for by variance in Self-Efficacy. Population r between these variables varies from .04 to .40.

c) ***Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge in Physics among Prospective Secondary School Teachers who have done Graduation with Physics as Subsidiary Subject***

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics among Prospective secondary school teachers who have graduated with Physics as a subsidiary subject are presented in Table 28.

Table 28

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among Prospective secondary school teachers who have done graduation with Physics as a subsidiary subject *(N = 275)*

Variables Compared with PCK in Physics	r	Fisher's t	Confidence Interval	Shared Variance
Pre-Internship Learner Engagement	.155*	4.07	(.05, .27)	2.56
Opportunity to achieve Learning Objectives	.204**	5.23	(.05, .35)	4.16
Opportunity to Learn Skills	.225**	5.8	(.08, .38)	5.06
Engagement during School Internship	.115	2.91	-	-
Accomplishments during School Internship	.102	2.59	-	-
Role of Teacher Educator	.120*	3.04	(-.01, .25)	1.44
Attitude towards Science	.368**	9.94	(.23, .49)	13.54
Self-Efficacy	.116	2.93	-	-
Teacher Motivation	.103	2.61	-	-

* indicates $P \leq 0.05$
** indicates $P \leq 0.01$

Table 28 reveals that the obtained coefficient of correlation for variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, and Role of Teacher Educator are low but positive and significant at 0.01 level or 0.05 level. The shared variance (2.56) for Pre-Internship Learner Engagement indicates that nearly three per cent of the variance in PCK in Physics is accounted for by variance in Pre-Internship Learner Engagement. Population r between these variables varies from .05 to .27. The shared variance (4.16) for Opportunity to achieve Learning objectives indicates that nearly four per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to achieve Learning objectives. Population r between these variables varies from .05 to .35.

The shared variance (5.06) for Opportunity to Learn skills indicates that approximately five per cent of the variance in PCK in Physics is accounted for by variance in Opportunity to Learn skills. Population r between these variables varies from .08 to .38. The shared variance (1.44) for Role of Teacher Educator indicates that approximately only one per cent of the variance in PCK in Physics is accounted for by variance in Role of Teacher Educator. Population r between these variables varies from -.01 to .25. The shared variance (13.54) for Attitude towards Science indicates that approximately 14 per cent of the variance in PCK in Physics is accounted for by variance in Attitude towards Science. Population r between these variables varies from .23 to .49.

d) *Relation of Select Institutional and Learner Related Factors with Pedagogical Content Knowledge in Physics among Prospective Secondary School Teachers who have Studied Physics Only Up to Class Twelve*

The results of Pearson's product-moment coefficient of correlation between select institutional and learner related factors and PCK in Physics among prospective secondary school teachers who have studied Physics only up to class twelve (12^{th} Physics) are presented in Table 29.

Table 29

Details of Relation Between Select Institutional and Learner Related Factors and PCK in Physics among prospective secondary school teachers who have studied Physics only up to class 12 *(N = 36)*

Variables Compared with PCK in Physics	r	Fisher's t	Confidence Interval	Shared Variance
Pre-Internship Learner Engagement	.316	8.35	-	-
Opportunity to achieve Learning Objectives	.311	8.22	-	-
Opportunity to Learn Skills	.117	2.97	-	-
Engagement during School Internship	.062	1.56	-	-
Accomplishments during School Internship	.426**	11.83	(.16, .70)	18.15
Role of Teacher Educator	.143	3.63	-	-
Attitude towards Science	.509**	1.85	(.17, .83)	25.91
Self-Efficacy	.156	3.97	-	-
Teacher Motivation	.481**	13.78	(.23, .73)	23.1

** indicates P ≤ 0.01

Table 29 reveals that the coefficient of correlation obtained for the variables Accomplishments during School Internship, Attitude towards Science, and Teacher Motivation are substantial, positive and significant at 0.01 level. All other cases are not significant, even at a 0.05 level. The shared variance (18.15) for Accomplishments during School Internship indicates that nearly 18 per cent of the variance in PCK in Physics is accounted for by variance in Accomplishments during School Internship. Population r between these variables varies from .16 to .70. The shared variance (25.91) for Attitude towards Science indicates that approximately 26 per cent of the variance in PCK in Physics is accounted for by variance in Attitude towards Science. Population r between these variables varies from .17 to .83. The shared variance (23.1) for Teacher Motivation indicates that approximately 23 per cent of the variance in PCK in Physics is accounted for by variance in Teacher Motivation. Population r between these variables varies from .23 to .73.

Table 30 shows the result of the test of significance of the difference between the coefficient of correlation between the relevant subgroups based on the Level of Physics studied.

Table 30

Test of Significance of Difference Between Coefficient of Correlation Between the Relevant Sub-groups based on Level of Physics Studied

Variables Compared with PCK in Physics	Pair of groups compared based on level of Physics studied					
	BSc-MSc Physics	BSc Phy-Sub Physics	BSc Phy-Phy up to 12^{th}	MSc-Sub Physcs	Msc-12^{th} physics	Sub-12^{th} Physics
Pre-Internship Learner Engagement	2.65**	0.24	0.73	3.30	0.86	0.88
Opportunity to achieve Learning Objectives	1.41	0.84	0.16	0.87	0.73	0.58
Opportunity to Learn Skills	2.03*	0.30	0.40	1.98*	1.60	0.59
Engagement during School Internship	1.60	1.11	0.87	3.10**	1.83	0.29
Accomplishments during School Internship	2.69**	0.64	2.16	2.42*	0.58	1.90
Role of Teacher Educator	2.26*	0.35	0.31	2.23*	1.04	0.13
Attitude towards Science	0.62	0.59	1.20	0.10	0.84	0.93
Self-Efficacy	0.09	1.17	0.42	1.06	0.34	0.22
Teacher Motivation	0.80	1.28	1.49	0.41	1.99**	2.27*

From Table 30 it is clear that there is significant difference between students having B.Sc. Physics and M.Sc. Physics qualification in Pre-internship Learner Engagement and Accomplishments during School Internship at 0.01 level. They also significantly differ at 0.05 level in Opportunity to Learn Skills and Role of Teacher Educator.

Postgraduates in physics and students who have done graduation with physics as subsidiary subject significantly differ in Engagement during School Internship

(0.01 level), Opportunity to Learn Skills (0.05 level), Accomplishments during School Internship (0.05 level) and Role of Teacher Educator (0.05 level).

There is significant difference (0.05 level) in teacher motivation between postgraduates in physics and students who have studied physics up to 12th level. Also, teacher motivation significantly differs between students who have studied physics as a subsidiary subject for their graduation and those who have studied physics only up to class twelve.

Discussion. A significant and positive correlation exists between Attitude towards Science (10%), Opportunity to achieve Learning Objectives (8%), Self-efficacy (6%), Teacher Motivation (5.48%), Engagement during School Internship (5.24%), Opportunity to Learn Skills (4%), Pre-Internship Learner Engagement (3.24%) and PCK in Physics in the sub-groups who have studied Physics as their main subject for graduation. The highest correlations are between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Self-Efficacy. Role of Teacher Educator and Accomplishments during School Internship has no significant relation with PCK in Physics.

A significant, positive but low correlation exists between Pre-Internship Learner Engagement (21.16%), Opportunity to achieve Learning Objectives (18.32%), Opportunity to Learn Skills (17%), Engagement during School Internship (15.21%), Attitude towards Science (14%), Role of Teacher Educator (11.42%), Accomplishments during School Internship (11.22%) and PCK in Physics in the sub-sample who have done post-graduation in Physics. The highest correlations are between the variable Pre-Internship Learner Engagement followed by Opportunity to achieve Learning Objectives and Opportunity to achieve Learn Skills. Teacher Motivation has no significant relation with PCK in Physics.

A significant positive but low correlation exists only between Select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science (14%), Opportunity to Learn Skills (5.06%), Opportunity to achieve Learning Objectives (4.16%), Pre-Internship Learner Engagement (3%) and Role of Teacher Educator (1.44%) in the sub-sample who have studied Physics only as a subsidiary subject during their graduation. The highest correlations are between the variable Attitude towards Science followed by Opportunity to achieve Learn Skills and Opportunity to achieve Learning Objectives.

A significant positive but low correlation exists only between Select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science (26%), Teacher Motivation (23.10%) and Accomplishments during School Internship (18.15%) in the sub-sample who have studied Physics only up to class twelfth. The highest correlations are between the variable Attitude towards Science followed by Teacher Motivation and Accomplishments during School Internship.

There is significant difference between students having B.Sc. Physics and M.Sc. Physics qualification in Pre-internship Learner Engagement and Accomplishments during School Internship at 0.01 level. They also significantly differ at 0.05 level in Opportunity to Learn Skills and Role of Teacher Educator.

Postgraduates in physics and students who have done graduation with physics as subsidiary subject significantly differ in Engagement during School Internship

(0.01 level), Opportunity to Learn Skills (0.05 level), Accomplishments during School Internship (0.05 level) and Role of Teacher Educator (0.05 level).

There is significant difference (0.05 level) in teacher motivation between postgraduates in physics and students who have studied physics up to 12^{th} level. Also, teacher motivation significantly differs between students who have studied physics as a subsidiary subject for their graduation and those who have studied physics only up to class twelve.

D. Significant Predictors of Pedagogical Content Knowledge in Physics among Prospective Secondary School Teachers and their Sub-groups

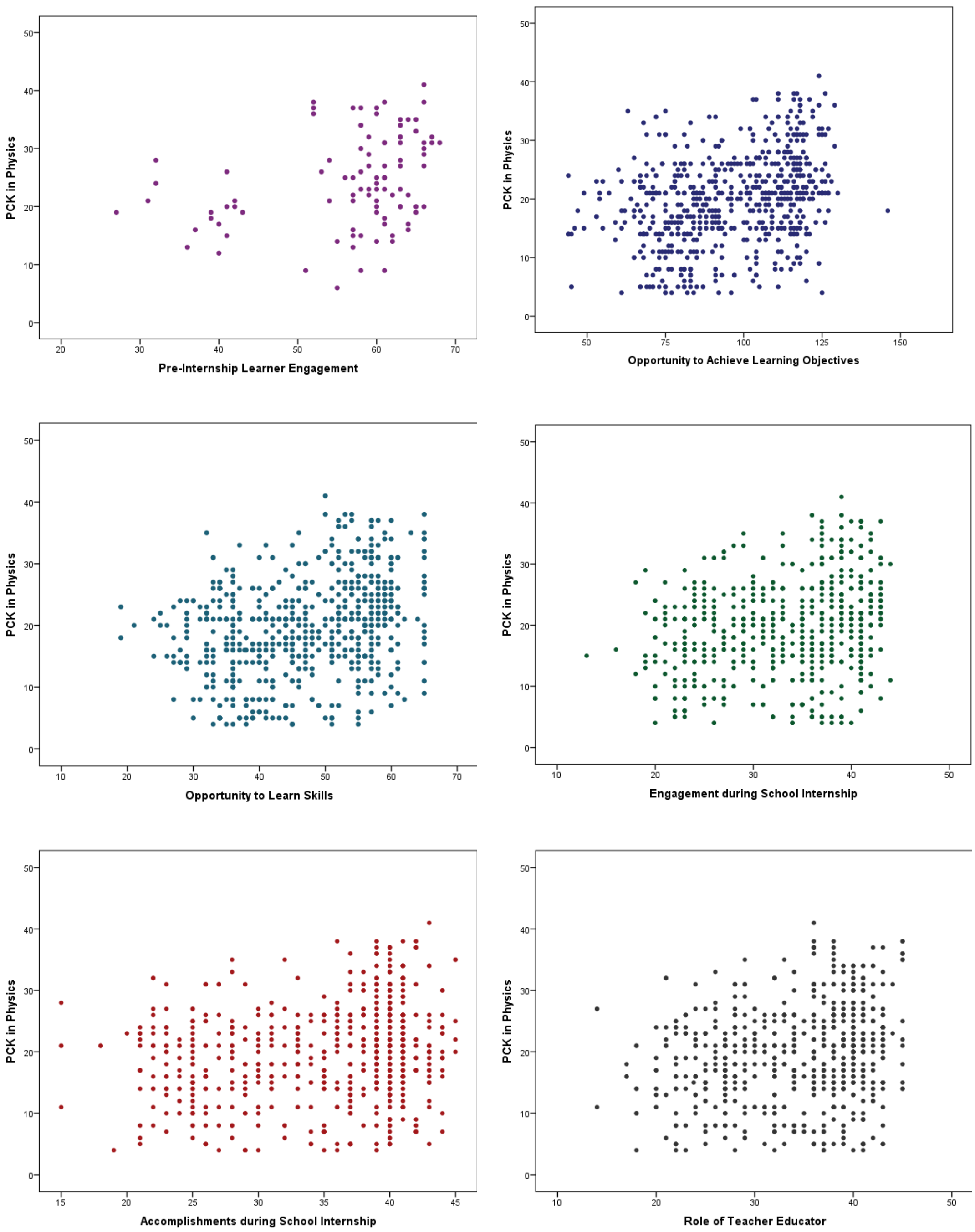
The third objective of the study is to find out the significant predictors of PCK in Physics among prospective secondary school teachers and sub-groups based on Gender and Level of Physics studied. Investigator used a multiple regression model to identify the significant predictors of PCK in Physics from the select institutional and learner-related factors. This strategy is used when the researcher has no logical or theoretical structure to the data. This method is typically used to explore and maximize prediction (Pedhazur, 1997). Multiple regression analysis theoretically warrants meeting some basic assumptions before carrying out the analysis. They are

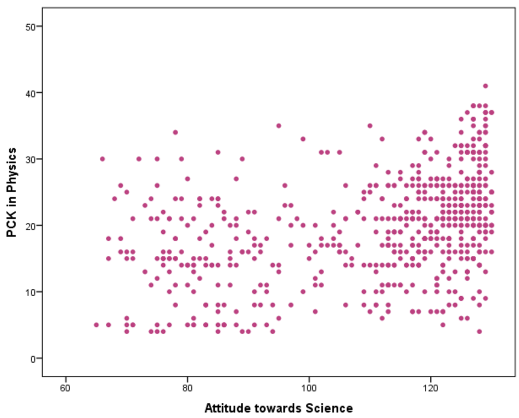
1. The relationship between the independent and dependent variables to be linear
2. Multivariate normality of all variables
3. No multicollinearity among the variables
4. No auto-correlation
5. Homoscedasticity

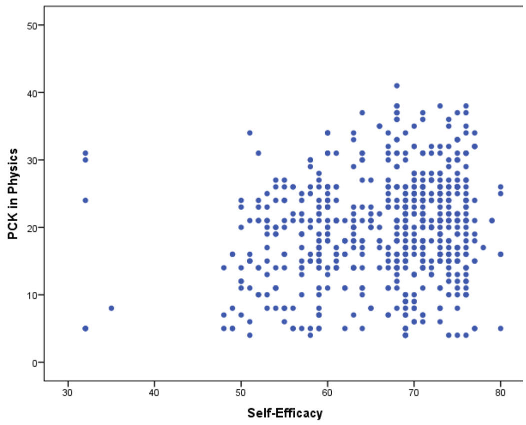
The data satisfied the assumption of a linear relationship, which is clear from Figure 4.

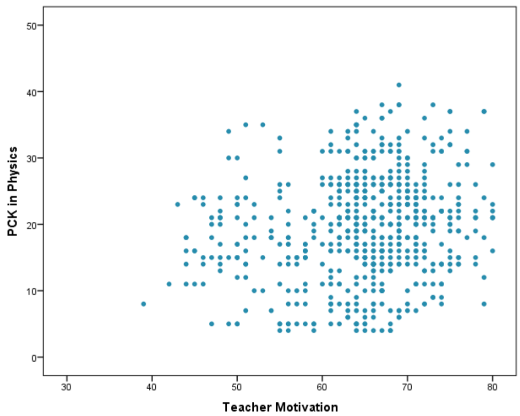
Figure 4

Scattergram of Select Institutional and Learner Related Variables and PCK in Physics





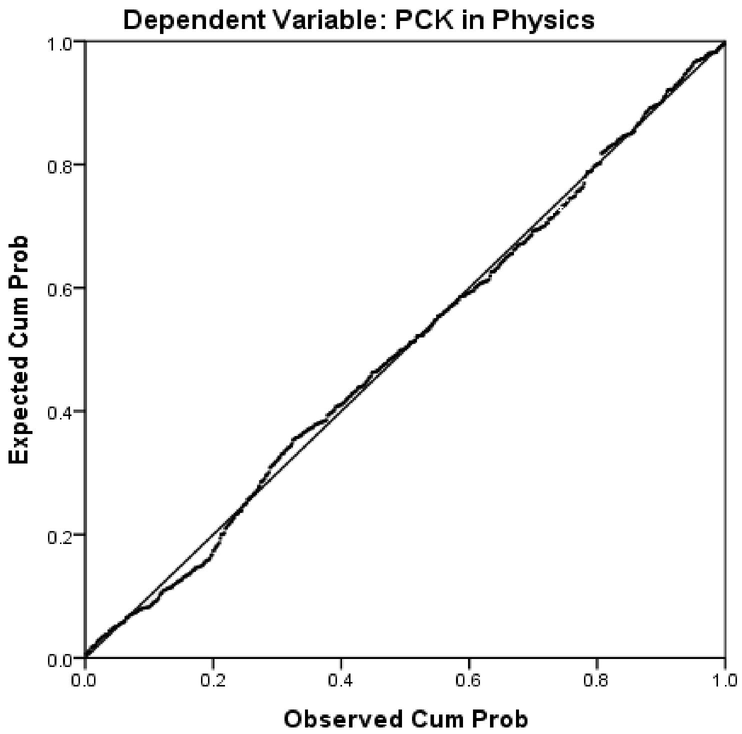




Multivariate normality of all the variables is established using a P-P plot, and it is given in Figure 5.

Figure 5

P-P Plot of Regression Standardised Residual



The absence of multicollinearity in the data is checked using Pearson's bivariate correlation matrix among the independent variables. The correlation matrix of the dependent variable with the predictor variables is given in Table 31.

Table 31

Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables

Correlations (Total)											
Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.305**	1								
Opportunity to achieve Learning Objectives	X_2	.337**	.558**	1							
Opportunity to Learn Skills	X_3	.308**	.558**	.545**	1						
Engagement during School Internship	X_4	.250**	.435**	.396**	.682**	1					
Accomplishments during School Internship	X_5	.199**	.458**	.408**	.626**	.714**	1				
Role of Teacher Educator	X_6	.204**	.461**	.374**	.623**	.727**	.756**	1			
Attitude towards Science	X_7	.396**	.399**	.568**	.405**	.275**	.303**	.271**	1		
Self-Efficacy	X_8	.202**	.346**	.435**	.365**	.280**	.315**	.305**	.448**	1	
Teacher Motivation	X_9	.188**	.211**	.370**	.211**	.098*	.120**	.117**	.563**	.264**	1

*indicates p≤0.05; ** indicates p≤0.01

The data of intercorrelation of criterion variable PCK in Physics with the predictor variables (Table 31) shows none of the correlations reached the .80 threshold, which suggests no two variables are highly related. Table 29 displays two other checks for multicollinearity of the predictive variables - tolerance levels and the Variance Inflation Factor (VIF) and Durbin Watson's d.

Table 32

Tolerance Level, Variation Inflation Factor and Durbin Watson's d of the Predictor Variables

Predictor variables	Tolerance	VIF	Durbin Watson's d
Attitude Towards Science	.792	1.262	
Opportunity to Learn Skills	.649	1.540	2.106
Pre-Internship Learner Engagement	.653	1.532	

The assumption is satisfied if the tolerance levels are below one and the VIF scores are below five. The tolerance and VIF values in Table 32 show no concern that the predictive variables excessively influence each other. Also, the Durbin Watson test statistic (2.106) obtained indicates that the autocorrelation in the set of data can be neglected.

The scattergrams of the predictor variables (Figure 3) establish homoscedasticity's assumption.

Multiple regression analysis was done for PCK in Physics by taking the select predictor variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation. The details of regression analysis for the total sample are given below.

The model summary of multiple regression analysis of the select variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation is presented in Table 33.

Table 33

Model Summary of Multiple Correlation Coefficient for PCK in Physics

R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics			
				R^2 Change	F Change	df_1	df_2
.438[c]	.192	.188	6.950	.009	7.036**	1	629

c- Predictors: (Constant), Attitude towards Science, Opportunity to Learn Skills, Pre-Internship Learner Engagement

From Table 33, it is clear that the multiple correlation coefficient obtained is .438, which is significant at the 0.01 level. Moreover, the predictor variables viz., Attitude towards Science, Opportunity to Learn Skills and Pre-Internship Learner Engagement explained 19.2 per cent of variance (R^2 =.192, F (49.753), $p \leq 0.01$) as joint contribution in predicting PCK in Physics among prospective secondary school teachers.

The regression weights obtained for the select institutional and learner related variables in predicting PCK in Physics are given in Table 34.

Table 34

Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics

Model	Unstandardised Coefficients		Standardised Coefficients	t	r	β×r
	B	Std. Error	Beta (β)			
(Constant)	-2.33	1.827		-1.275		
Attitude Towards Science	0.126	0.017	0.300	7.457**	0.396	0.119
Opportunity to Learn Skills	0.091	0.034	0.120	2.704**	0.308	0.037
Pre-Internship Learner Engagement	0.081	0.031	0.118	2.652**	0.305	0.036
					∑β×r=	0.192

*N*ote: ** denotes p≤ 0.01

In the case of Attitude towards Science, a B weight of .126 indicates a positive relationship between Attitude towards Science and PCK in Physics. For a change in Attitude towards Science by one unit, PCK in Physics changes by .126 units. When the Attitude towards Science increases by one unit, PCK in Physics increases by .126 units if the effects of all other predictor variables are kept constant.

In the case of Opportunity to Learn Skills, a B weight of .091 indicates a positive relationship between Opportunity to Learn Skills and PCK in Physics. For a change in Opportunity to Learn Skills by one unit, PCK in Physics changes by .091 units. When the Opportunity to Learn Skills increases by one unit, PCK in Physics increases by .091 units keeping the effects of all other predictor variables constant.

In the case of Pre-Internship Learner Engagement, a B weight of .081 indicates a positive relationship between Pre-Internship Learner Engagement and PCK in

Physics. For a change in Work done during B.Ed by one unit, PCK in Physics changes by .081 units. When the Pre-Internship Learner Engagement increases by one unit, PCK in Physics increases by .081 units, keeping the effects of all other predictor variables constant.

Based on the non-standard coefficients we obtain regression equation as

$$Y' = \quad -2.33 + .126X_7 + .91X_3 + .81X_1$$

Where,

Y' = Predicted value of PCK in Physics

X_7 = Attitude towards Science,

X_3 = Opportunity to Learn Skills,

X_1 = Pre-Internship Learner Engagement

Table 34 also shows the standardized beta value of Attitude towards Science (β = 0.300), Opportunity to Learn Skills (β = 0.120) and Pre-Internship Learner Engagement (β = 0.118). Hence the regression equation can be re-written based on standardized beta value as:

$$Z' = \quad .300Z_7 + 0.138Z_3 + 0.118Z_1$$

Z' = Standardized Predicted value of PCK in Physics

Z_7 = Standardized score of Attitude towards Science,

Z_3 = Standardized score of Opportunity to Learn Skills,

Z_1 = Standardized score of Pre-Internship Learner Engagement

From Table 34 t value corresponding to standardized coefficient beta (β) value for Attitude towards Science (t = 7.457), Opportunity to Learn Skills (t = 2.704) and Pre-Internship Learner Engagement (t = 2.652) are greater than 2.56, and hence significant at 0.01 level.

R^2 and adjusted R^2 were calculated to determine the amount of variation in the model's outcome variable. The Model summary given in Table 33 shows that the difference between R^2 and adjusted R^2 obtained is .009 (0 per cent), which implies that approximately no variance will be there in the outcome if the model were derived from the population than the sample. This means that the cross validity of the model is good.

Predictive Efficiency of the Significant Predictors

The multiple correlations between criterion variable Y and three predictor variables viz., Attitude towards Science (X_7), Opportunity to Learn Skills (X_3) and Pre-Internship Learner Engagement (X_1), as given in Table 34 of the previous section, suggests that PCK in Physics among prospective secondary school teachers can be significantly predicted utilizing the three predictor variables $X_{7,}$ $X_{3,}$ and X_1.

The coefficient of multiple determination (R^2) in terms of 'β's and 'r's was computed for determining the relative efficiency of each of these three predictor variables ($X_{7,}$ $X_{3,}$ and X_1) in predicting PCK in Physics among prospective secondary school teachers.

Table 35

Beta Coefficients, Coefficients of Correlation and their Products Showing Relative Efficiency of Predictor Variables

Variable Number	Predictor Variable	Beta Coefficient	Coefficient of Correlation (r)	$\beta \times r$
X_7	Attitude towards Science	0.3	0.396	0.119
X_3	Opportunity to Learn Skills	0.12	0.308	0.037
X_1	Pre-Internship Learner Engagement	0.118	0.305	0.036
			$\sum \beta \times r = R^2$	0.192

From Table 35 it is found that $\sum \beta \times r = R^2 = 0.192$. which means 19 per cent of whatever makes prospective secondary school teachers differ in their PCK in Physics is attributable to differences in Attitude towards Science (X_7), Opportunity to Learn Skills (X_3) and Pre-Internship Learner Engagement (X_1). Around 19.2 per cent of the variation in prospective secondary school teachers' PCK in Physics is the contribution of the three predictor variables obtained as predictors in stepwise regression analysis. The remaining 80.8 per cent of the variation in PCK in Physics is attributable to variation in other variables not included in the study.

The relative efficiency of the five significant predictor variables, as suggested by the product $\beta \times r$ in Table 35 in predicting prospective secondary school teachers' PCK in Physics can be summarised as follows:

i. 11.9 per cent of variation (out of 19.2 per cent variation attributable to the three predictor variables) in prospective secondary school teachers' PCK in Physics is contributed by Attitude towards Science.

ii. 3.7 per cent of variation (out of 19.2 per cent variation attributable to the three predictor variables) in prospective secondary school teachers' PCK in Physics is contributed by Opportunity to Learn Skills.

iii. 3.6 per cent of variation (out of 19.2 per cent variation attributable to the three predictor variables) in prospective secondary school teachers' PCK in Physics is contributed by Pre-Internship Learner Engagement.

Thus, out of the three significant predictor variables, Attitude towards Science is the best predictor of prospective secondary school teachers' PCK in Physics. The second-best predictor of prospective secondary school teachers' PCK in Physics is Opportunity to Learn Skills, and the third is Pre-Internship Learner Engagement. The three significant predictor variables are listed below in the order of relative efficiency in predicting prospective secondary school teachers' PCK in Physics.

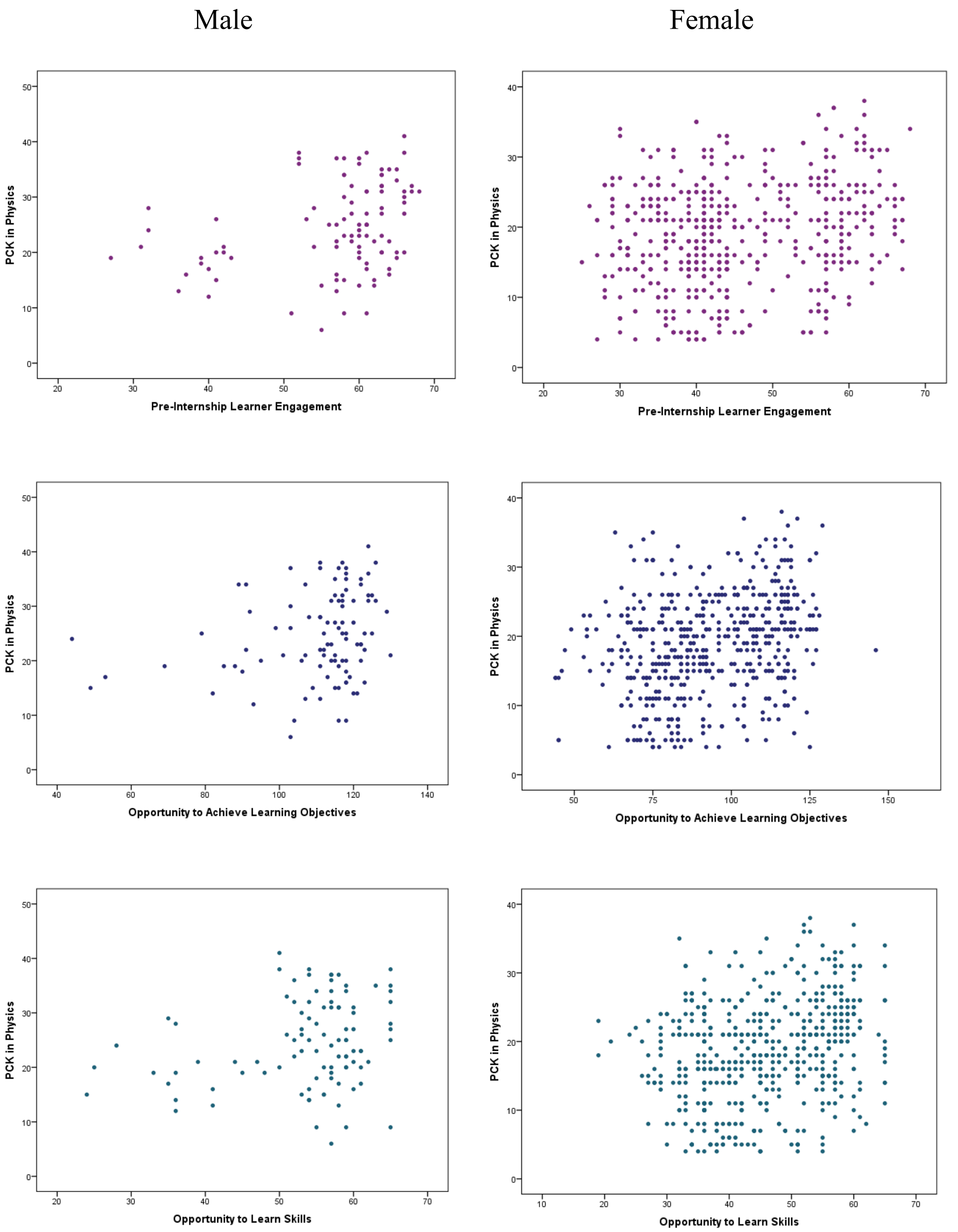
1. Attitude towards Science
2. Opportunity to Learn Skills, and
3. Pre-Internship Learner Engagement

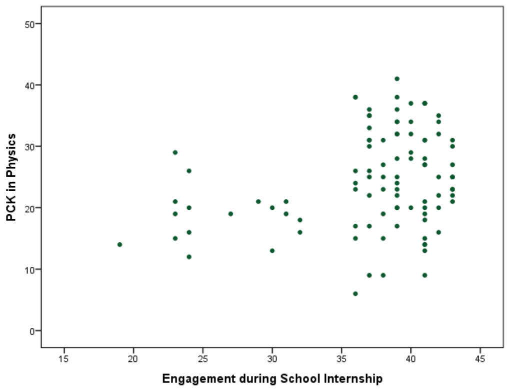
Significant Predictors of Pedagogical Content Knowledge in Physics among Prospective Secondary School Teachers Based on Their Gender

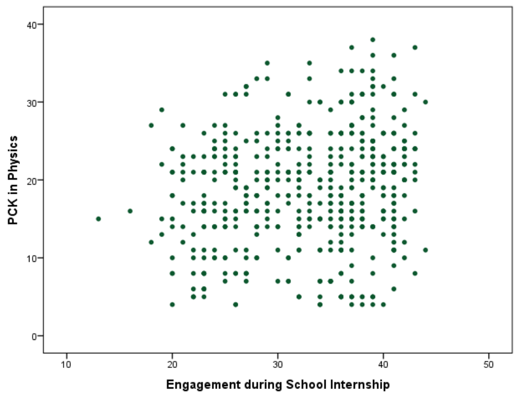
To identify the significant predictors of PCK in Physics from the select institutional and learner related factors, the investigator used a multiple regression model for sub-groups based on Gender. It was ensured that the variables fulfiled all the critical assumptions needed for doing multiple regression. Scattergram of select institutional and learner related variables and PCK in physics is given as Figure 6.

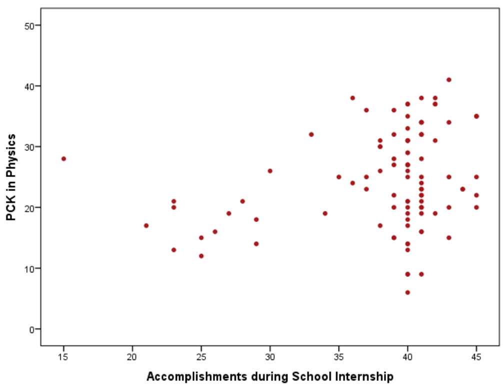
Figure 6

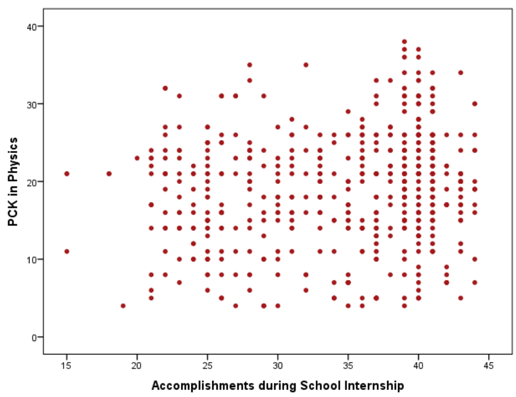
Scattergram of Select Institutional and Learner Related Variables and PCK in Physics

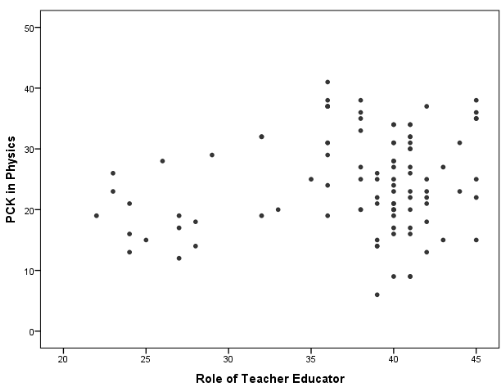


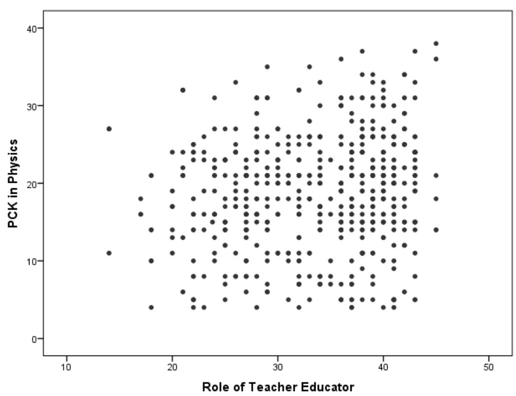

PCK in Physics
0 10 20 30 40 50
15 20 25 30 35 40 45
Engagement during School Internship

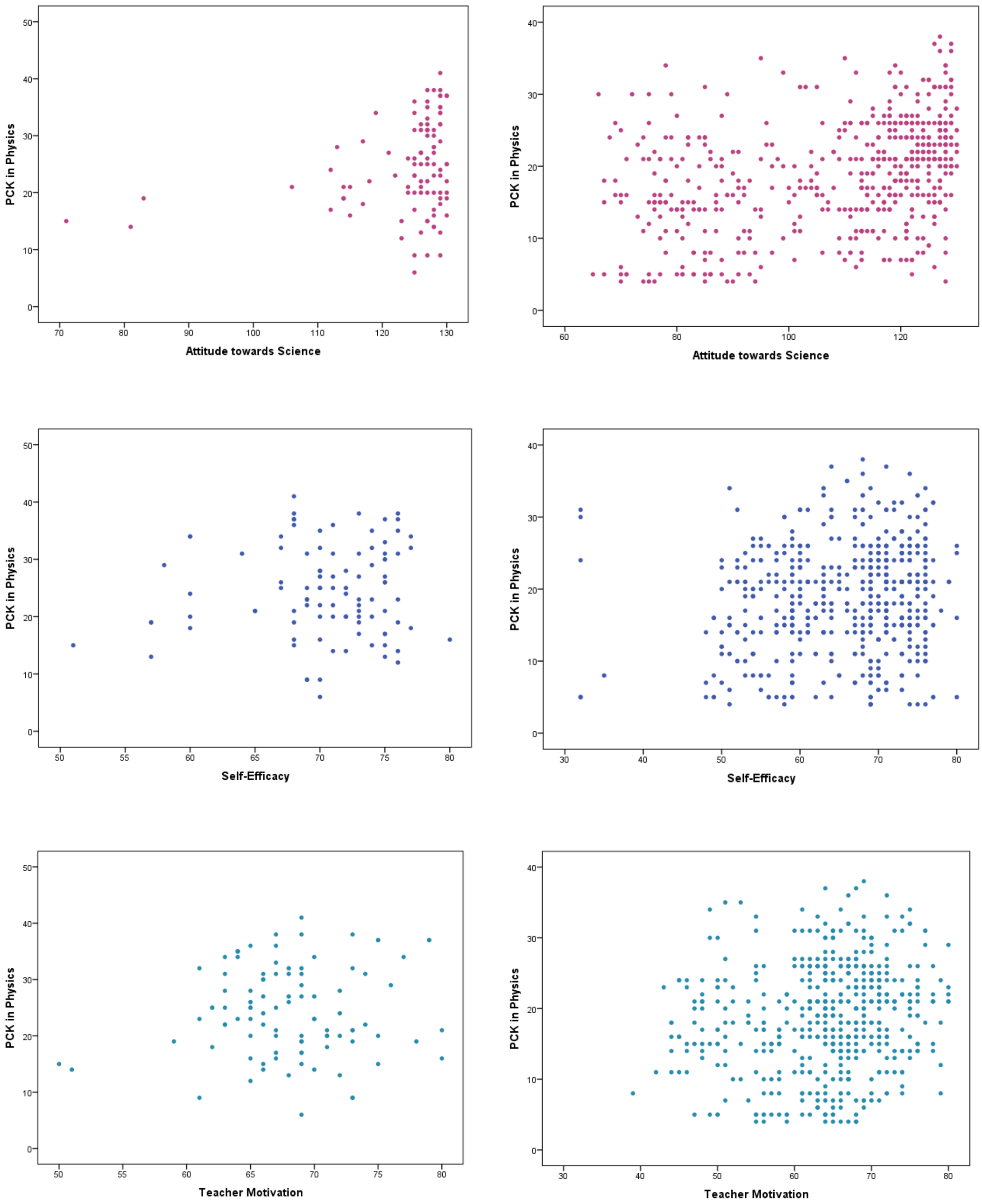

PCK in Physics
0 10 20 30 40
10 20 30 40 50
Engagement during School Internship


PCK in Physics
0 10 20 30 40 50
15 20 25 30 35 40 45
Accomplishments during School Internship


PCK in Physics
0 10 20 30 40
15 20 25 30 35 40 45
Accomplishments during School Internship


PCK in Physics
0 10 20 30 40 50
20 25 30 35 40 45
Role of Teacher Educator

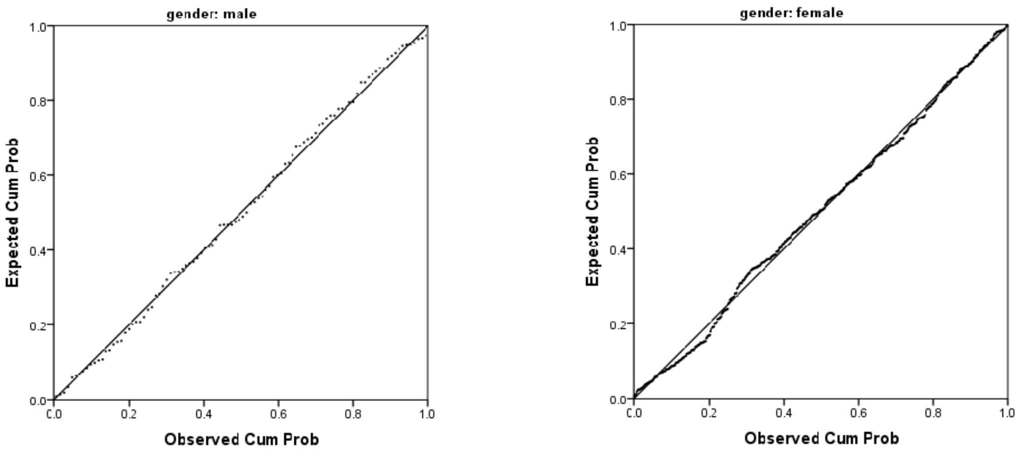

PCK in Physics
0 10 20 30 40
10 20 30 40 50
Role of Teacher Educator



Multivariate normality of all the variables is established using the P-P plot, given in Figure 7.

Figure 7

P-P Plot of Regression Standard Residual for Male and Female



The data satisfied the assumption of a linear relationship, and it is clear from Figure 6. The scattergrams of the predictor variables (Figure 6) establish the assumption of homoscedasticity. As all the assumptions of multiple regression analysis are satisfied, the investigator decided to carry out the regression analysis.

The absence of multicollinearity in the data is checked using Pearson's bivariate correlation matrix among the independent variables. The correlation matrix of the dependent variable with the predictor variables based on Gender is given in Table 36 and Table 37.

Table 36

Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables for Prospective Secondary School Male Teachers

Correlations											
Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.320**	1								
Opportunity to Achieve Learning Objective	X_2	.239*	.603**	1							
Opportunity to Learn Skills	X_3	.246*	.671**	.656**	1						
Engagement during School Internship	X_4	.288**	.561**	.430**	.702**	1					
Accomplishments during School Internship	X_5	.260**	.728**	.432**	.707**	.588**	1				
Role of Teacher Educator	X_6	.182	.574**	.407**	.677**	.681**	.724**	1			
Attitude Towards Science	X_7	.269**	.484**	.626**	.569**	.509**	.477**	.468**	1		
Self-Efficacy	X_8	.077	.415**	.440**	.353**	.198	.208*	.147	.402**	1	
Teacher Motivation	X_9	.085	.067	.211*	.175	.218*	.172	.031	.405**	.104	1

*indicates p≤0.05; ** indicates p≤0.01

Table 37

Correlation Matrix of the Dependent Variable PCK in Physics with the Predictor Variables for Prospective Secondary School Female Teachers

Correlations											
Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.210**	1								
Opportunity to achieve Learning Objectives	X_2	.284**	.486**	1							
Opportunity to Learn Skills	X_3	.253**	.483**	.481**	1						
Engagement during School Internship	X_4	.184**	.356**	.337**	.653**	1					
Accomplishments during School Internship	X_5	.136**	.378**	.362**	.592**	.714**	1				
Role of Teacher Educator	X_6	.149**	.396**	.319**	.588**	.715**	.747**	1			
Attitude towards Science	X_7	.359**	.310**	.519**	.335**	.196**	.242**	.202**	1		
Self-Efficacy	X_8	.168**	.285**	.396**	.327**	.247**	.293**	.284**	.415**	1	
Teacher Motivation	X_9	.158**	.168**	.349**	.171**	.042	.078	.086*	.552**	.245**	1

*indicates p≤0.05; ** indicates p≤0.01

The data of intercorrelation of criterion variable PCK in Physics with the predictor variables (Table 36 and 37) shows none of the correlations reached the .80 threshold, which suggests no two variables are highly related. Table 38 displays two other checks for multicollinearity of the predictive variables - tolerance levels and the Variance Inflation Factor (VIF). Tolerance Level, Variation Inflation Factor and Durbin Watson's d of the Predictor Variables are given in Table 38.

Table 38

Tolerance Level, Variation Inflation Factor and Durbin Watson's d of the Predictor Variables

Gender	Predictor Variables	Collinearity Statistics		Durbin-Watson
		Tolerance	VIF	
Male	Pre-Internship Learner Engagement	1.000	1.000	1.853
Female	Attitude towards Science	.888	1.126	1.922
	Opportunity to Learn Skills	.888	1.126	

If the tolerance levels are below one and the VIF scores are below five, the assumption is satisfied. The tolerance and VIF values in Table 35 show no reason for concern that the predictive variables excessively influence each other. Also, the Durbin Watson test statistics 1.853 (male) and 1.922 (female) obtained indicates that the autocorrelation in the set of data can be neglected.

The scattergrams of the predictor variables (Figure 5) establish the assumption of homoscedasticity.

Multiple regression analysis was done for PCK in Physics by taking the select predictor variables viz., Pre-Internship Learner Engagement, Opportunity to achieve

Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation.

The details of regression analysis are given below.

The model summary of multiple regression analysis of the select variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation is presented in Table 39.

Table 39

Model Summary of Multiple Correlation Coefficient for PCK in Physics based on Gender

Gender	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics			
					R^2 Change	F Change	df_1	df_2
Male	0.320	0.102	0.093	7.588	0.102	10.961**	1	96
Female	0.385	0.149	0.145	6.782	0.020	12.366**	1	532

a. Predictors: (Constant), Pre-Internship Learner Engagement
d. Predictors: (Constant), Attitude towards Science, Opportunity to Learn Skills

From Table 39, it is clear that the multiple correlation coefficient obtained is .320 (male) and .385 (female). Both are significant at a 0.01 level. In the case of prospective secondary school male teachers, the predictor variable explained 10.2 per cent of variance (R^2 = .102, F (10.961), $p \leq 0.01$) is the contribution of Pre-Internship Learner Engagement in predicting PCK in Physics. For prospective secondary school female teachers, the predictor variables explained 10.2 per cent of variance (R^2 = .102, F (46.427), $p \leq 0.01$) with the joint contribution of Attitude towards Science and Opportunity to Learn Skills.

The regression weights obtained for the select institutional and learner related variables in predicting PCK in Physics based on their Gender are given in Table 40.

Table 40

Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics based on their Gender

Gender	Predictor Variables	Unstandardised Coefficients		Standardised Coefficients Beta (β)	t	r	β×r
		B	Std. Error				
Male	(Constant)	9.064	4.722		1.92		
	Pre-Internship Learner Engagement	0.272	0.082	0.320	3.311**	0.32	0.102
					$\sum \beta \times r = R^2$	=	0.102
Female	(Constant)	0.564	1.919		0.294		
	Attitude towards Science	0.122	0.017	0.309	7.276**	0.359	0.111
	Opportunity to Learn Skills	0.11	0.031	0.149	3.516**	0.253	0.038
					$\sum \beta \times r = R^2$	=	0.149

Table 40 shows that for prospective secondary school male teachers, the predictor variable Pre-Internship Learner Engagement having a B weight of .272 indicates a positive relationship between Pre-Internship Learner Engagement and PCK in Physics. For a change in Pre-Internship Learner Engagement by one unit, PCK in Physics changes by .272 units. When the Pre-Internship Learner Engagement increases by one unit, PCK in Physics increases by .272 units, keeping the effects of all other predictor variables constant.

In the case of prospective secondary school female teachers, the predictor variable Attitude towards Science having a B weight of .122 indicates a positive relationship between Attitude towards Science and PCK in Physics. For a change in Attitude towards Science by one unit, PCK in Physics changes by .122 units. When the Attitude towards Science increases by one unit, PCK in Physics increases by .122 units if the effects of all other predictor variables are kept constant.

For prospective secondary school female teachers, the predictor variable Opportunity to Learn Skills having a B weight of .110 indicates a positive relationship between Opportunity to Learn Skills and PCK in Physics. For a change in Opportunity to Learn Skills by one unit, PCK in Physics changes by .110 units. When Opportunity to Learn Skills increases by one unit, PCK in Physics increases by .110 units, keeping the effects of all other predictor variables constant.

Based on the non-standard coefficient, we obtain regression equations for both male and female prospective secondary school teachers as

$$Y' = 9.064 + .272X_1 \text{ (male)}$$
$$Y' = 0.564 + .122X_7 + .110X_3 \text{ (female)}$$

Where,

Y' = Predicted value of PCK in Physics

X_1 = Pre-Internship Learner Engagement,

X_7 = Attitude towards Science,

X_3 = Opportunity to Learn Skills,

Table 40 shows the corresponding standardized beta value of Pre-Internship Learner Engagement for prospective secondary school male teachers as β = 0.320, and for prospective secondary school female teachers, the standardized beta value of Attitude towards Science and Opportunity to Learn Skills are as β = 0.309 and 0.149 respectively. Hence the regression equations can be re-written based on standardized beta values as:

$Z' = .320Z_1$ (male)

$Z' = .309Z_7 + 0.149Z_3$ (female)

Z' = Standardized Predicted value of PCK in Physics

Z_1 =Standardized score of Pre-Internship Learner Engagement

Z_7 = Standardized score of Attitude towards Science

Z_3 = Standardized score of Opportunity to Learn Skills

From Table 40, t value corresponding to the standardised coefficient beta (β) value for Attitude towards Science (t = 7.276), Opportunity to Learn Skills (t = 3.516) and Pre-Internship learner Engagement (t = 3.311) is greater than 2.56 and hence significant at 0.01 level.

R^2 and adjusted R^2 were calculated to determine the amount of variation in the model's outcome variable. The Model summary given in Table 39 shows that difference between R^2 and adjusted R^2 obtained is .102 and .320, which implies that for prospective male secondary school teachers, approximately ten per cent variance will be there in the outcome if the model were derived from the population than sample and for prospective secondary school female teachers approximately no variance will be there in the outcome if the model were derived from the population than the sample. This means that the cross validity of the model is good.

Predictive Efficiency of the Significant Predictors

The multiple correlations between criterion variable Y and predictor variable Pre-Internship Learner Engagement (X_1) in case of prospective secondary school male teachers and variables Attitude towards Science (X_7) and Opportunity to Learn Skills (X_3) in case of prospective secondary school female teachers, as given in Table 40 of the previous section suggests that PCK in Physics among prospective secondary school male teachers can be significantly predicted using the predictor variable X_1. Variables X_3 and X_7 can predict PCK in Physics among secondary school female teachers.

The coefficient of multiple determination (R^2) in terms of 'β's and 'r's was computed for determining the relative efficiency of each of these predictor variables in predicting PCK in Physics of prospective male and female secondary school teachers, given in Table 40.

From Table 37, it is found that for prospective secondary school male teachers $\sum \beta \times r = R^2 = 0.102$. This, in turn, means that ten per cent of what makes prospective secondary school male teachers differ in their PCK in Physics is attributable to differences in Pre-Internship Learner Engagement (X_1). That is, around 10.2 per cent of the variation in prospective secondary school male teachers' PCK in Physics is the contribution of the predictor variable obtained as predictors in stepwise regression analysis. The remaining 89.8 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

From Table 40, it is found that for prospective secondary school female teachers $\sum \beta \times r = R^2 = 0.149$. This, in turn, means that approximately 15 per cent of what makes prospective female secondary school teachers differ in their PCK in Physics is attributable to differences in Attitude towards Science (X_7) and Opportunity to Learn Skills (X_3). Around 15 per cent of the variation in prospective secondary school female teachers' PCK in Physics is the contribution of the two predictor variables obtained as predictors in stepwise regression analysis. The remaining 85 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

The relative efficiency of the significant predictor variables, as suggested by the product $\beta \times r$ in Table 40 in predicting prospective secondary school teachers' PCK in Physics, can be summarized as follows:

i. 10.2 per cent of the variation in prospective secondary school male teachers' PCK in Physics is contributed by Attitude towards Science.

ii. 11.1 per cent of variation (out of 14.9 per cent variation attributable to the two predictor variables) in prospective secondary school female teachers' PCK in Physics is contributed by Attitude towards Science.

iii. 3.8 per cent of variation (out of 14.9 per cent variation attributable to the two predictor variables) in prospective secondary school female teachers' PCK in Physics is contributed by Opportunity to Learn Skills.

Thus, in the case of prospective secondary school male teachers, Pre-Internship Learner Engagement is a significant predictor variable. Out of the two significant predictor variables for prospective secondary school female teachers, Attitude towards Science is the best predictor of prospective secondary school teachers' PCK in Physics, followed by Opportunity to Learn Skills.

Significant Predictors of Pedagogical Content Knowledge in Physics of Prospective Secondary School Teachers Based on Level of Physics Studied

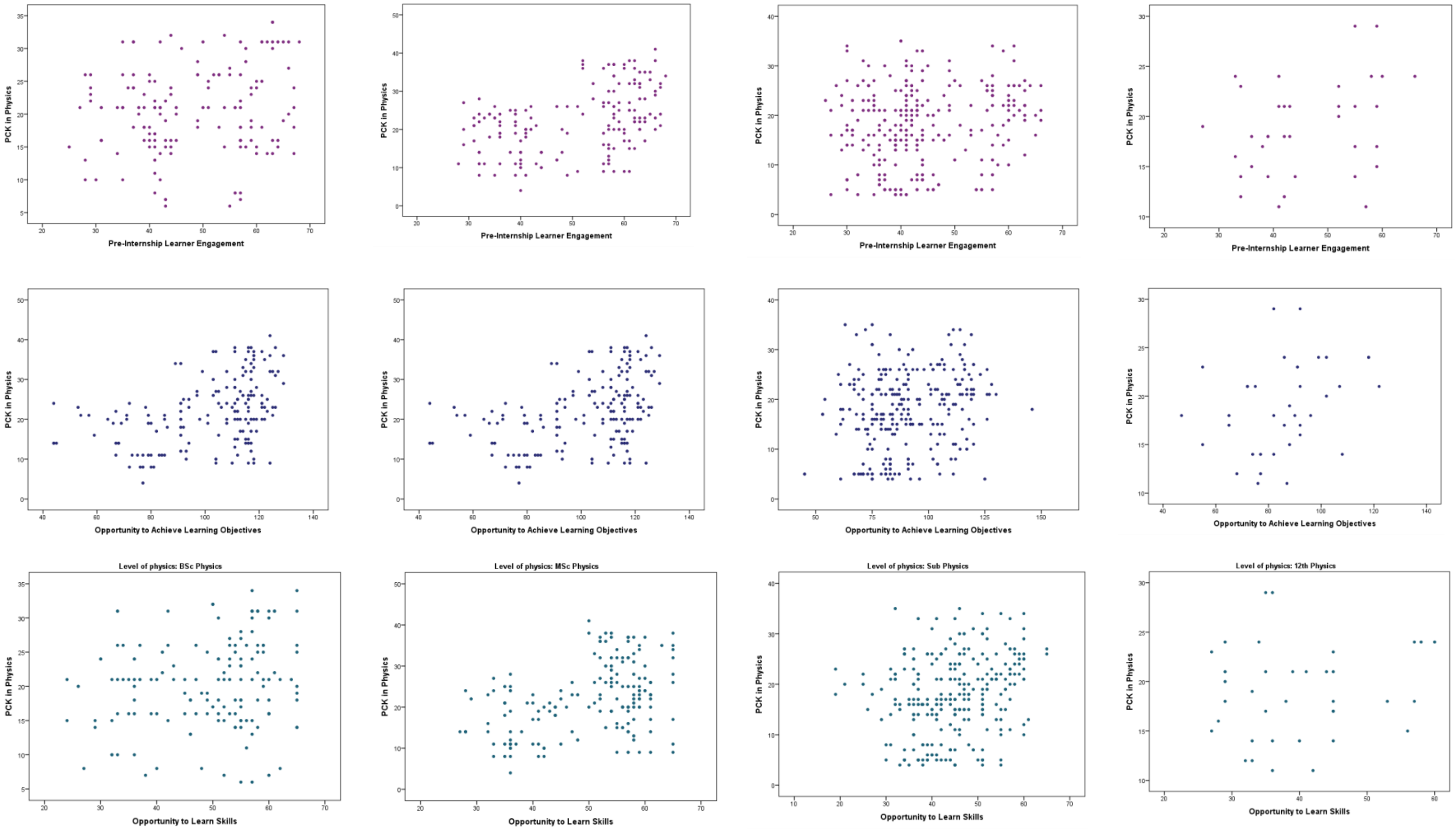
To determine the significant predictors of PCK in Physics among prospective secondary school teachers for sub-groups based on the Level of Physics studied and to determine which institutional and learner related factors had a statistically significant relationship to PCK in physics, the investigator used a multiple regression model.

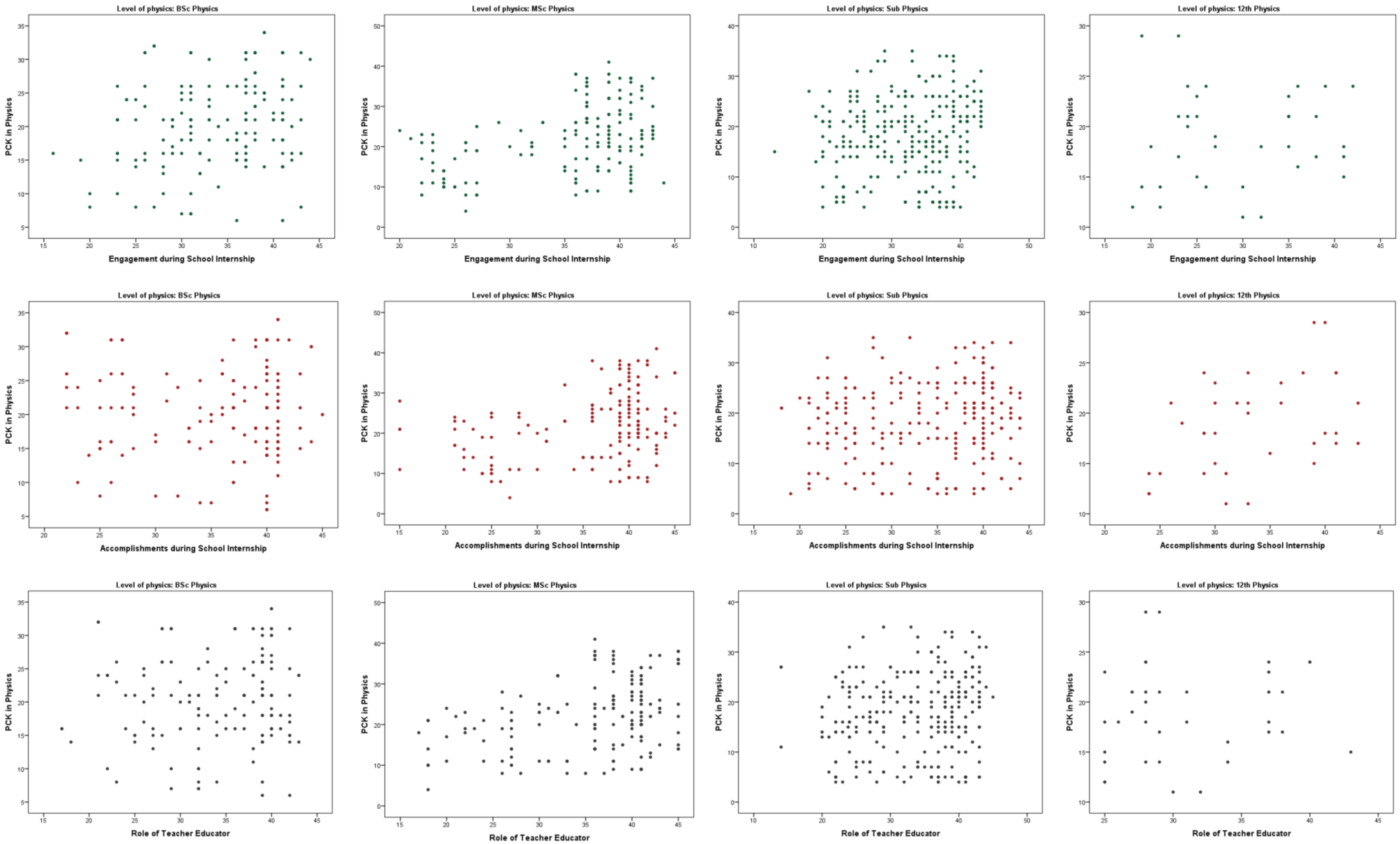
The data satisfied the assumption of a linear relationship, and it is clear from Figure 8. Multivariate normality of all the variables was established using the P-P plot, and it is given in Figure 9. The scattergrams of the predictor variables (Figure 8) establish the assumption of homoscedasticity. As all the assumptions of multiple regression analysis are satisfied, the investigator decided to carry out the regression analysis.

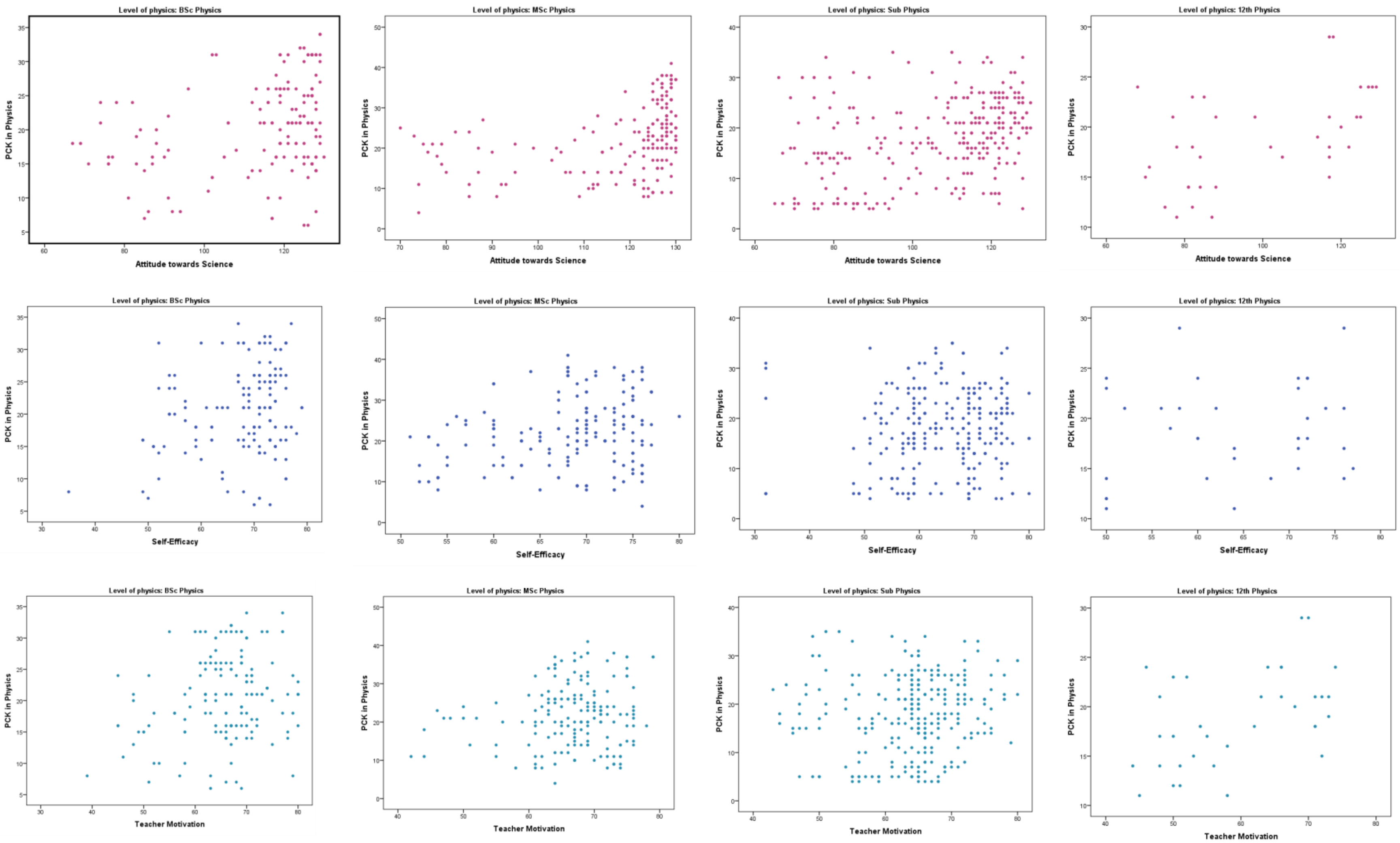
Figure 8

Scattergrams of Select Institutional and Learner Related Variables and PCK in Physics

BSc Physics | MSc Physics | Sub. Physics | 12th Physics



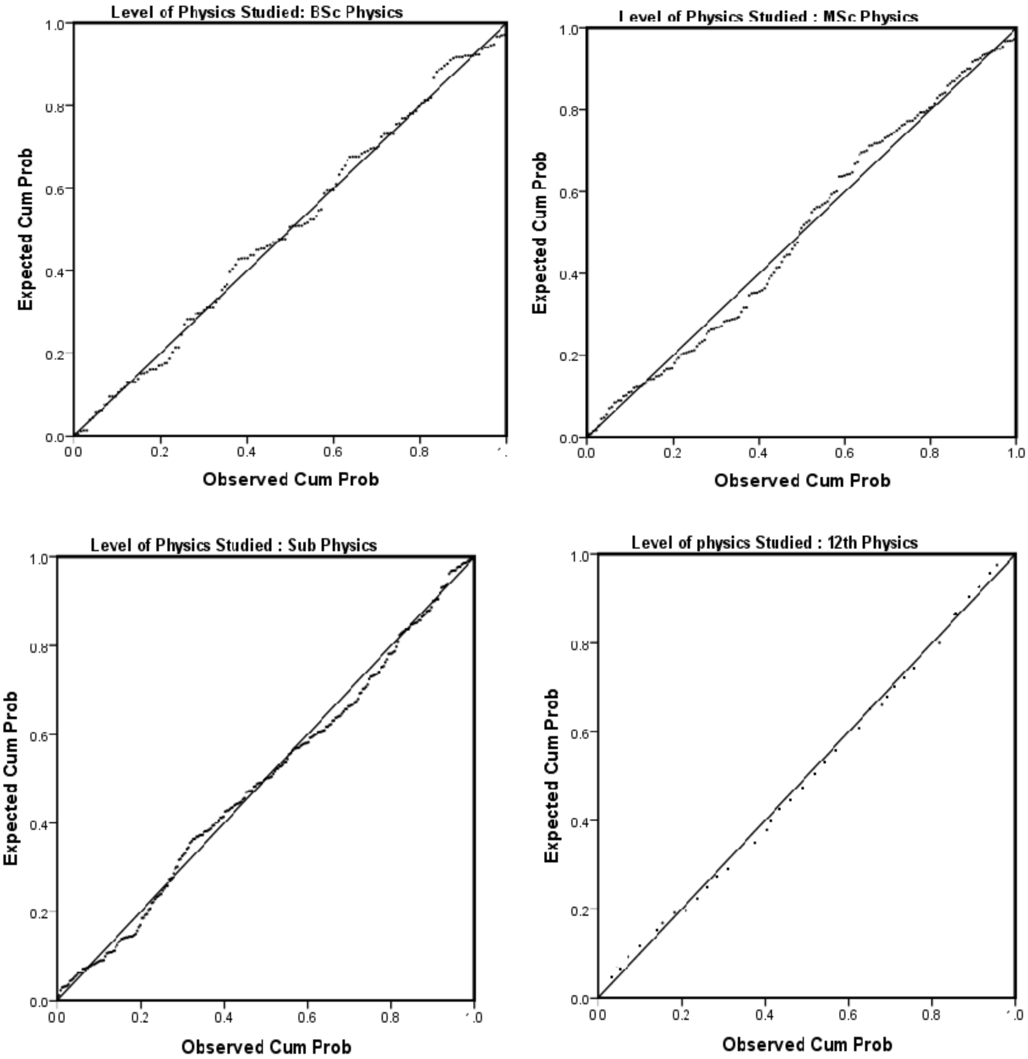

Level of physics: BSc Physics
Level of physics: MSc Physics
Level of physics: Sub Physics
Level of physics: 12th Physics
PCK in Physics
Engagement during School Internship
Level of physics: BSc Physics
Level of physics: MSc Physics
Level of physics: Sub Physics
Level of physics: 12th Physics
PCK in Physics
Accomplishments during School Internship
Level of physics: BSc Physics
Level of physics: MSc Physics
Level of physics: Sub Physics
Level of physics: 12th Physics
PCK in Physics
Role of Teacher Educator



Level of physics: BSc Physics
Level of physics: MSc Physics
Level of physics: Sub Physics
Level of physics: 12th Physics
PCK in Physics
Attitude towards Science
Self-Efficacy
Teacher Motivation

Figure 9

P- P plot of Regression Standardised Residuals



The absence of multicollinearity in the data is checked using Pearson's bivariate correlation matrix among the independent variables. The correlation matrices of the dependent variable with the predictor variables based on the Level of Physics studied are given in Table 41, Table 42, Table 43 and Table 44.

Table 41

Correlation Matrix of the Dependent Variable with the Predictor Variables for BSc Physics Group

Correlations (BSc Physics)											
Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.180*	1								
Opportunity to Achieve Learning Objective	X_2	.280**	.628**	1							
Opportunity to Learn Skills	X_3	.194*	.622**	.609**	1						
Engagement during School Internship	X_4	.229**	.611**	.615**	.720**	1					
Accomplishments During School Internship	X_5	.036	.523**	.571**	.664**	.750**	1				
Role of Teacher Educator	X_6	.084	.564**	.580**	.640**	.751**	.823**	1			
Attitude Towards Science	X_7	.315**	.426**	.711**	.510**	.451**	.421**	.453**	1		
Self-Efficacy Belief	X_8	.236**	.284**	.520**	.394**	.477**	.492**	.515**	.529**	1	
Teacher Motivation	X_9	.234**	.184*	.528**	.320**	.303**	.272**	.284**	.692**	.393**	1

*indicates p≤0.05; ** indicates p≤0.01

Table 42

Correlation Matrix of the Dependent Variable with the Predictor Variables for MSc Physics Group

Correlations (MSc Physics)

Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.455**	1								
Opportunity to Achieve Learning Objective	X_2	.428**	.670**	1							
Opportunity to Learn Skills	X_3	.409**	.738**	.595**	1						
Engagement during School Internship	X_4	.390**	.546**	.361**	.632**	1					
Accomplishments during School Internship	X_5	.335**	.634**	.435**	.637**	.661**	1				
Role of Teacher Educator	X_6	.338**	.605**	.396**	.705**	.738**	.799**	1			
Attitude Towards Science	X_7	.370**	.598**	.663**	.527**	.382**	.551**	.526**	1		
Self-Efficacy	X_8	.220**	.512**	.486**	.436**	.285**	.487**	.446**	.569**	1	
Teacher Motivation	X_9	.143	.272**	.306**	.179*	.132	.356**	.206**	.564**	.286**	1

*indicates p≤0.05; ** indicates p≤0.01

Table 43

Correlation Matrix of the Dependent Variable with the Predictor Variables for the Subsample who studied Physics as Subsidiary

Correlations (Sub Physics)

Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.155*	1								
Opportunity to Achieve Learning Objective	X_2	.204**	.370**	1							
Opportunity to Learn Skills	X_3	.225**	.337**	.359**	1						
Engagement during School Internship	X_4	.115	.247**	.212**	.645**	1					
Accomplishments during School Internship	X_5	.102	.246**	.248**	.598**	.734**	1				
Role of Teacher Educator	X_6	.120*	.285**	.190**	.531**	.682**	.693**	1			
Attitude Towards Science	X_7	.368**	.148*	.353**	.126*	.011	.029	-.023	1		
Self-Efficacy	X_8	.116	.208**	.335**	.249**	.108	.086	.101	.314**	1	
Teacher Motivation	X_9	.103	.109	.211**	-.004	-.179**	-.180**	-.111	.426**	.121*	1

*indicates p≤0.05; ** indicates p≤0.01

Table 44

Correlation Matrix of the Dependent Variable with the Predictor Variables for the Subsample who studied Physics up to 12th level

Correlations (12th Physics)											
Variables		Y^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
PCK in Physics	Y^1	1									
Pre-Internship Learner Engagement	X_1	.316	1								
Opportunity to Achieve Learning Objective	X_2	.311	.370*	1							
Opportunity to Learn Skills	X_3	.117	.313	.507**	1						
Engagement during School Internship	X_4	.062	.110	.380*	.744**	1					
Accomplishments during School Internship	X_5	.426**	.507**	.446**	.514**	.671**	1				
Role of Teacher Educator	X_6	.143	.349*	.545**	.746**	.886**	.766**	1			
Attitude Towards Science	X_7	.509**	.566**	.554**	.505**	.318	.535**	.386*	1		
Self-Efficacy	X_8	.156	.495**	.185	.331*	.403*	.624**	.482**	.363*	1	
Teacher Motivation	X_9	.481**	.262	.460**	.355*	.230	.252	.224	.620**	.306	1

*indicates p≤0.05; ** indicates p≤0.01

The data of intercorrelation of criterion variable PCK in Physics with the predictor variables (Table 41 to Table 44) shows none of the correlations reached the .80 threshold, which suggests no two variables are highly related. Table 45 displays two other checks for multicollinearity of the predictive variables - tolerance levels and the Variance Inflation Factor (VIF) and Durbin Watson test statistic. The assumption is satisfied if the tolerance levels are below one and the VIF scores are below five. The tolerance and VIF values in Table 45 show no reason for concern that the predictive variables excessively influence each other. Also, Durbin Watson test statistics 2.017 (for BSc Physics), 1.892 (for MSc Physics), 1.445 (for Sub Physics), and 1.864 (12^{th} Physics) obtained indicates that the autocorrelation in the set of data can be neglected.

Table 45

Tolerance Level, Variation Inflation Factor and Durbin Watson's d of the Predictor Variables

Level of Physics studied	Predictor Variables	Collinearity Statistics		Durbin-Watson
		Tolerance	VIF	
BSc Physics	Attitude towards Science	1	1	2.017
MSc Physics	Pre-Internship Learner Engagement	0.445	2.248	1.892
	Engagement during School Internship	0.702	1.424	
	Opportunity to Achieve Learning objective	0.551	1.816	
Sub Physics	Attitude towards Science	0.984	1.016	1.445
	Opportunity to Learn Skills	0.984	1.016	
12^{th} Physics	Attitude towards Science	1	1	1.864

Multiple regression analysis was done for PCK in Physics by taking the select predictor variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation.

The details of regression analysis are given below.

The model summary of multiple regression analysis of the select variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation is presented in Table 46.

Table 46

Model Summary of Multiple Correlation Coefficient for PCK in Physics based on Level of Physics studied

Level of Physics Studied	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics			
					R^2 Change	F	df_1	df_2
BSc Physics	.315	0.099	0.093	6.3	0.099	16.371**	1	149
MSc Physics	.513	0.263	0.25	7.256	0.028	19.909**	3	167
Sub Physics	.410	0.168	0.162	7.085	0.033	27.408**	2	272
12^{th} Physics	.509	0.259	0.237	4.084	0.259	11.874**	1	34

From Table 46, it is clear that the multiple correlation coefficient obtained is .315 (for BSc Physics), .513 (for MSc Physics), .410 (for Sub Physics) and .509 (for 12^{th} Physics) are significant at a 0.01 level. In the case of prospective secondary school teachers who have studied Physics as the main subject for graduation (BSc Physics), the predictor variable explained 31.5 per cent of variance ($R^2 = .315$, F(16.371), $p \leq 0.01$) contribution of Attitude towards Science in predicting PCK in Physics. For prospective secondary school teachers who have post-graduation in Physics, the predictor variables explained 51.3 per cent of variance ($R^2= .513$, F (19.909), $p \leq 0.01$) with the joint contribution of Pre-Internship Learner Engagement, Engagement during School Internship and Opportunity to achieve Learning Objectives. For prospective secondary school teachers who have studied Physics as a subsidiary subject for their graduation, the predictor variables explained 41 per cent of variance ($R^2= .410$, F (27.408), $p \leq 0.01$) with the joint contribution of Attitude towards Science and Opportunity to Learn skills. For prospective secondary school teachers who have studied Physics as a subject only up to the 12^{th} level, the predictor variable Attitude towards Science explained 51 per cent of variance ($R^2= .509$, F (11.874), $p \leq 0.01$) of PCK in Physics.

The regression weights obtained for the select institutional and learner related variables in predicting PCK in Physics based on the Level of Physics studied are given in Table 47.

Table 47

Regression Weights Obtained for Select Institutional and Learner Related Variables in Predicting PCK in Physics

Level of Physics studied	Predictor Variables	Unstandardized Coefficients		Standardized Coefficients Beta (β)	t	r	β×r
		B	Std. Error				
BSc Physics	(Constant)	6.351	3.537		1.796		
	Attitude Towards Science	0.124	0.031	.315	4.046**	.315	.099
					$\sum \beta \times r = R^2$	=	.099
MSc Physics	(Constant)	-3.876	3.66	-	-1.059		
	Pre-Internship Learner Engagement	.135	0.07	.192	1.931	.455	.087
	Engagement during School Internship	.268	0.105	.203	2.560**	.39	.079
	Opportunity to Achieve Learning objectives	.093	0.037	.226	2.529**	.428	.096
					$\sum \beta \times r = R^2$	=	.262
Sub Physics	(Constant)	-4.403	3.095	-	-1.423		
	Attitude towards Science	.144	0.023	.345	6.181**	.368	.126
	Opportunity to Learn Skills	.157	0.048	.182	3.265**	.225	.04
					$\sum \beta \times r = R^2$	=	.166
12^{th} Physics	(Constant)	7.385	3.391	-	2.178**		
	Attitude Towards Science	.116	0.034	.509	3.446**	.509	.259
					$\sum \beta \times r = R^2$	=	.259

In the case of prospective secondary school teachers who have done graduation with Physics as the main subject (BSc Physics), the predictor variable Attitude towards Science having a B weight of .124 indicates a positive relationship between Attitude towards Science and PCK in Physics. For a change in Attitude towards Science by one unit, PCK in Physics changes by .124 units. When the Attitude towards Science increases by one unit, PCK in Physics increases by .124 units, keeping the effects of all other predictor variables constant.

In the case of prospective secondary school teachers who have post-graduation in Physics (MSc Physics), the predictor variable Pre-Internship Learner Engagement having a B weight of .135 indicates a positive relationship between Pre-Internship Learner Engagement and PCK in Physics. For a change in Pre-Internship Learner Engagement by one unit, PCK in Physics changes by .135 units. That is, When the Pre-Internship Learner Engagement increases by one unit, PCK in Physics increases by .135 units, if the effects of all other predictor variables are kept constant.

The predictor variable Engagement during School Internship having a B weight of .268 indicates a positive relationship between Engagement during School Internship and PCK in Physics. For a change in Engagement during School Internship by one unit, PCK in Physics changes by .268 units. When the Engagement during School Internship increases by one unit, PCK in Physics increases by .268 units, if the effects of all other predictor variables are kept constant.

The predictor variable Opportunity to Achieve Learning Objectives, having a B weight of .093, indicates a positive relationship between Opportunity to Achieve Learning Objectives and PCK in Physics. For a change in Opportunity to Achieve

Learning Objectives by one unit, PCK in Physics changes by .093 units. When the Opportunity to Achieve Learning Objectives increases by one unit, PCK in Physics increases by .093 units, if the effects of all other predictor variables are kept constant. Three variables, Pre-Internship Learner Engagement, Engagement during School Internship and Opportunity to Achieve Learning objectives ($\sum \beta \times r = R^2 = 26.2$) contribute significantly towards variance in PCK in Physics.

From Table 47, we can find that for prospective secondary school teachers who have studied physics as a subsidiary subject up to graduation, the predictor variable Attitude Towards Science having a B weight of .144 indicates a positive relationship between Attitude Towards Science and PCK in Physics. For a change in Attitude Towards Science by one unit, PCK in Physics changes by .144 units. When the Attitude Towards Science by one unit, PCK in Physics increases by .144 units, if the effects of all other predictor variables are kept constant. The predictor variable Opportunity to learn Skills having a B weight of .157 indicates a positive relationship between Opportunity to learn Skills and PCK in Physics. For a change in Opportunity to learn Skills by one unit, PCK in Physics changes by .157 units. When the Opportunity to learn Skills increases by one unit, PCK in Physics increases by .157 units, keeping the effects of all other predictor variables constant.

In the case of prospective secondary school teachers who have studied Physics up to twelfth class, the predictor variable Attitude towards Science having B weight of .116 indicates a positive relationship between Attitude towards Science and PCK in Physics. For a change in Attitude towards Science by one unit, PCK in Physics changes by .116 units. When the Attitude towards Science increases by one unit, PCK in Physics increases by .116 units, keeping the effects of all other predictor variables constant.

Based on the non-standard coefficient, we obtain regression equations for the sub-group based on the Level of Physics studied as

$Y' = 6.351 + .124X_7$ (BSc Physics)

$Y' = -3.876 + .135X_1 + .268X_4 + .093X_2$ (MSc Physics)

$Y' = -4.403 + .144X_7 + .157X_3$ (Sub Physics)

$Y' = 7.385 + .116X_7$ (12^{th} Physics)

Where,

Y^1 = Predicted value of PCK in Physics

X_1 = Pre-Internship Learner Engagement,

X_2 = Opportunity to achieve Learning Objectives

X_3 = Opportunity to Learn Skills,

X_4 = Engagement during School Internship

X_7 = Attitude towards Science,

Table 47 shows for prospective secondary school teachers who have studied Physics as their main subject for graduation, the corresponding standardized beta value of Attitude Towards Science is $\beta = .315$, and for prospective secondary school teachers who have post-graduation in Physics, the standardized beta value of Pre-Internship Learner Engagement, Engagement during School Internship and Opportunity to achieve Learning Objectives are as $\beta = .192$, .203 and .226 respectively. In the case of prospective secondary school teachers who have studied physics as a subsidiary subject up to the graduation, the standardized beta value of

Attitude Towards Science and Opportunity to Learn Skills are β = .182 and .345, respectively, and for prospective secondary school teachers who have studied Physics up to twelfth class standardized beta value of Attitude Towards Science is β = .509. Hence the regression equations can be re-written based on standardized beta values as:

$Z' = \quad .315Z_7$

$Z' = \quad .192Z_1 + 0.203Z_4 + .226Z_2$

$Z' = \quad .345Z_7 + 0.182Z_3$

$Z' = \quad .509Z_7$

Z' = Standardized Predicted value of PCK in Physics

Z_1 =Standardized score of Pre-Internship Learner Engagement

Z_2 = Standardized score of Opportunity to Achieve Learning Objectives

Z_4 = Standardized score of Engagement during School Internship

Z_3 = Standardized score of Opportunity to Learn Skills,

Z_7 = Standardized score of Attitude Towards Science,

From Table 47, the t value corresponding to all standardized coefficient beta (β) values corresponding to all four categories are greater than 2.56, and hence significant at 0.01 level except for Pre-Internship Learner Engagement (1.931) in the category MSc physics.

R^2 and adjusted R^2 were calculated to determine the amount of variation in the model's outcome variable. The Model summary given in Table 47 shows that difference between R^2 and adjusted R^2 obtained is .099, .028, .033 and .259, which implies that except for prospective secondary school teachers who have studied

Physics only up to class twelfth, approximately no variance will be there in the outcome if the model were derived from the population than the sample. This means that the cross validity of the model is good.

Predictive Efficiency of the Significant Predictors

The coefficient of multiple determination (R^2) in terms of 'β's and 'r's was computed to determine the relative efficiency of each predictor variable in predicting PCK in Physics among prospective secondary school teachers based on the Level of Physics Studied.

From Table 47, it is found that for prospective secondary school teachers having graduated in Physics (BSc Physics) $\sum \beta \times r = R^2 = .099$ This, in turn, means that ten per cent of whatever that makes prospective secondary school teachers having graduated in Physics to differ in their PCK in Physics is attributable to differences in Attitude towards Science (X_7). Around 9.9 per cent of the variation in PCK in Physics among prospective secondary school teachers having graduated in Physics is the contribution of the predictor variable obtained as predictors in stepwise regression analysis. The remaining 90.1 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

From Table 47, it is found that for prospective secondary school teachers who have done post-graduation Physics (MSc Physics) $\sum \beta \times r = R^2 = .262$. This, in turn, means that approximately twenty-six per cent of whatever that makes prospective secondary school teachers having post-graduation in Physics differ in their PCK in Physics is attributable to differences in Pre-Internship Learner Engagement (X_1), Engagement during School Internship (X_4) and Opportunity to achieve Learning Objectives (X_2). That is, around twenty-six per cent of the variation in PCK in Physics of prospective secondary school teachers having post-graduation in Physics is the contribution of the three predictor variables obtained as predictors in stepwise regression analysis. The remaining 74 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

From Table 47, it is found that for prospective secondary school teachers who have done graduation with Physics as a subsidiary subject (Sub Physics) $\sum \beta \times r = R^2 = .166$. This, in turn, means that approximately seventeen per cent of what makes prospective secondary school teachers having studied Physics as a subsidiary subject during graduation differ in their PCK in Physics is attributable to differences in Attitude towards Science (X_7) and Opportunity to Learn Skills (X_3). That is, around seventeen per cent of the variation in PCK in Physics among prospective secondary school teachers having post-graduation in Physics is the contribution of the two predictor variables obtained as predictors in stepwise regression analysis. The remaining 83 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

From Table 47, it is found that for prospective secondary school teachers, those who have studied Physics up to class twelfth as a subject (12^{th} Physics) $\sum \beta \times r = R^2 = .259$. This, in turn, means that twenty-six per cent of what makes prospective secondary school teachers who graduated in Physics differ in their PCK in Physics is attributable to differences in Attitude towards Science (X_7). That is around 26 per cent of the variation in PCK in Physics of prospective secondary school teachers who have studied Physics only up to class twelfth is the contribution of the predictor variable Attitude towards Science, obtained as a predictor in stepwise regression analysis. The remaining 74 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study.

Summary of Major Findings

The study findings revealed that the extent of PCK in Physics among prospective secondary school teachers is meagre. The same trend is repeated in the case of components viz., Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge. Student teachers' mean scores are nearly half of the maximum score or below half for all three components. Of the selected sample, the student teachers who have done post-graduation in Physics have higher PCK in Physics, followed by those who have graduated with Physics as the main subject.

A significant but low positive correlation exists between each of the select institutional and learner related factors and PCK in Physics among prospective secondary school teachers. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills. Teacher Motivation has negligible correlation with prospective secondary school teachers' PCK in Physics.

The study findings also revealed that prospective secondary school male teachers have greater PCK in Physics (total and component-wise) than their female counterparts and the difference is significant.

The study's findings also revealed a significant and positive correlation between Select institutional and learner-related factors and PCK in Physics in the sub-samples based on Gender. For female prospective secondary school teachers, the highest correlations are found between the variables Attitude towards Science and PCK in Physics, followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills. Accomplishments during School Internship have the least correlation with prospective female secondary school teachers' PCK in Physics. For male prospective secondary school teachers, the highest correlations are found between the variables Pre-Internship Learner Engagement and PCK in Physics, followed by Engagement during School Internship and Attitude towards Science. The correlation between the Role of Teacher Educator and Teacher Motivation with prospective male secondary school teachers' PCK in Physics is negligible.

There is a significant gender difference in the extent of the relationship between Pre-Internship Learner Engagement, Engagement during School Internship and Accomplishments during School Internship and PCK in Physics. The relationship between the above three variables and PCK in Physics is higher among male prospective secondary school teachers than their counterparts.

A significant and positive correlation exists between each of the Attitude towards Science, Opportunity to achieve Learning Objectives, Self-Efficacy, Teacher Motivation, Engagement during School Internship, Opportunity to Learn Skills, Pre-Internship Learner Engagement and PCK in Physics in the sub-groups who have studied Physics as their main subject for graduation. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Self-Efficacy. Role of Teacher Educator and Accomplishments during School Internship has no significant relation with PCK in Physics.

A significant, positive but low correlation exists between Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Attitude towards Science, Role of Teacher Educator, Accomplishments during School Internship and PCK in Physics in the subgroup who have done post-graduation in Physics. The highest correlations are found between the variable Pre-Internship Learner Engagement followed by Opportunity to achieve Learning Objectives and Opportunity to achieve Learn Skills. Teacher Motivation has no significant relation with PCK in Physics.

A significant positive but low correlation exists only between select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science, Opportunity to Learn Skills, Opportunity to achieve Learning Objectives, Pre-Internship Learner Engagement and Role of Teacher Educator in the subgroup who have studied Physics only as a subsidiary subject during their graduation. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learn Skills and Opportunity to achieve Learning Objectives.

A significant positive but low correlation exists only between select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science, Teacher Motivation and Accomplishments during School Internship in the sub-group who have studied Physics only up to class twelfth. The highest correlations are found between the variable Attitude towards Science followed by Teacher Motivation and Accomplishments during School Internship.

PCK in Physics (Z') among prospective secondary school teachers can be predicted from three Variables viz., Attitude towards Science (Z_7), Opportunity to Learn Skills (Z_3) and Pre-Internship Learner Engagement (Z_1) using the formula,

$$Z' = .300Z_7 + 0.138Z_3 + 0.118Z_1$$

The multiple correlation (R) between the PCK in Physics among prospective secondary school teachers and three significant (predictor) institutional and learner related variables is .438, which is highly significant with a standard error of 6.95.

Prospective secondary school male teacher's PCK in Physics (Z') can be predicted from the Variable Pre-Internship Learner Engagement (Z_1) using the formula,

$$Z' = .320Z_1$$

The multiple correlation (R) between the PCK in Physics of prospective secondary school male teachers and predictor variable Pre-Internship Learner Engagement is .320, which is highly significant with a standard error of 7.58.

PCK in Physics of prospective secondary school female teachers (Z') can be predicted from two Variables viz., Attitude towards Science (Z_7) and Opportunity to Learn Skills (Z_3) using the formula,

$$Z' = .309Z_7 + 0.149Z_3$$

The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) related institutional variables is .385, highly significant with a standard error of 6.782.

PCK in Physics (Z') of prospective secondary school teachers who have done their graduation with Physics as the main subject can be predicted from the Variable Attitude towards Science (Z_7) using the formula,

$$Z' = .315Z_7$$

The multiple correlations (R) between the PCK in Physics of prospective secondary school teachers who graduated with Physics as the main subject and predictor variable Attitude towards Science is .315, highly significant with a standard error of 6.3.

PCK in Physics of prospective secondary school teachers who have done their post-graduation in Physics (Z') can be predicted from three Variables viz., Pre-Internship Learner Engagement (Z_1), Engagement during School Internship (Z_4) and Opportunity to Achieve Learning Objectives (Z_2) using the formula,

$$Z' = .192Z_1 + 0.203Z_4 + .226Z_2$$

The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) related institutional variables is .513, highly significant with a standard error of 7.256.

PCK in Physics of prospective secondary school teachers who have done their graduation with Physics as a subsidiary subject (Z') can be predicted from two

Variables viz., Attitude towards Science (Z_7) and Opportunity to Learn Skills (Z_3) using the formula,

$$Z' = .345Z_7 + 0.182Z_3$$

The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) related institutional variables is .410, highly significant with a standard error of 7.085.

PCK in Physics (Z'') of prospective secondary school teachers who have studied Physics up to twelfth class can be predicted from the Variable Attitude towards Science (Z_7) using the formula,

$$Z' = .509Z_7$$

The study findings revealed the multiple correlation (R) between the PCK in Physics of prospective secondary school teachers who have studied Physics up to twelfth class and predictor variable Pre-Internship Learner Engagement is .509, highly significant with a standard error of 4.084.

Tenability of Hypotheses

1. The first hypothesis states that "a significant relationship exists between select institutional and learner related variables and PCK in Physics".

The coefficient of correlation (Pearson's r) obtained between PCK in Physics and each of the nine variables revealed that all the nine variables have a significant correlation with PCK in Physics. Thus, the first hypothesis is substantiated.

2. The second hypothesis states that "PCK in Physics can be significantly predicted from the select set of variables."

The regression analysis showed that three out of nine institutional and learner related variables, viz., Attitude towards Science, opportunity to Learn Skills and Pre-internship Learner Engagement, are significant predictors of PCK in Physics among prospective secondary school teachers. In the subgroups based on gender, the predictor of PCK in physics among prospective male secondary school teachers is Pre-internship Learner Engagement, and for female candidates, predictors are Attitude towards Science and Opportunity to Learn Skills. In the subgroups based on Level of Physics studied for prospective secondary school teachers who have graduated in physics and those who have studied physics only up to twelfth, the significant predictor is Attitude towards Science. In the case of post-graduates in physics, the significant predictors are Pre-internship Learner Engagement, Engagement during School internship and opportunity to Achieve learning Objectives. Thus, the second hypothesis is substantiated.

SUMMARY AND FINDINGS

This chapter highlights the significant stages of the study, important findings, their educational implications and suggestions for further research.

Restatement of the Problem

The study was entitled **"Factors Affecting Pedagogical Content Knowledge in Physics Among Prospective Teachers at Secondary Level in Kerala."**

Teacher quality and teacher professionalism have been a major discussion in education. The reforms in the school curriculum demand more competent and professional teachers for its proper implementation and success. The researcher wanted to study teacher preparation based on how much our teacher education programmes contribute to the development of Pedagogical Content Knowledge (PCK) in Physics among prospective secondary school teachers in Kerala. The study paves light on how much today's teacher education programme contributes to PCK in Physics among prospective secondary school teachers and identifies the institutional and learner-related factors contributing to the enhancement of PCK among pre-service teachers. PCK has been identified as a vital component of teacher knowledge that can define teacher competence and professionalism.

Variables

The dependent and independent variables of the study were as follows

The dependent variable in the study was Pedagogical Content Knowledge (PCK) in Physics.

The independent variables are given under the two headings, viz., institutional and learner related factors

Institutional Factors

Pre-Internship Learner Engagement

Opportunity to achieve Learning Objectives.

Opportunity to Learn Skills.

Engagement during School Internship.

Accomplishments during School internship

Role of Teacher

Teacher Motivation

Learner related Factors

Attitude towards Science.

Self-Efficacy

Gender and Level of Physics studied were taken as classificatory variables.

Objectives

The study's major objective was to identify the factors affecting Pedagogical Content Knowledge in Physics of prospective secondary school teachers.

Following are the specific objectives of the study.

1. To find out the extent of Pedagogical Content Knowledge (PCK) in Physics among prospective secondary school teachers and their sub-groups based on

   a. Gender, and

   b. Level of Physics studied.

2. To find out the extent of the relationship between each of the institutional and learner related variables and PCK in Physics among prospective secondary school teachers and their sub-groups based on

   a. Gender, and

   b. Level of Physics studied

3. To identify the significant institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and sub-groups based on

   a. Gender, and

   b. Level of Physics studied

4. To develop a regression equation for predicting PCK in Physics among prospective secondary school teachers and their sub-groups with the select institutional and learner related variables.

5. To find out the relative efficiency of the select institutional and learner related variables in predicting PCK in Physics among prospective secondary school teachers and their relevant sub-groups.

Hypotheses

1. There will be a significant relationship between each of the select variables and PCK in Physics for the total group and sub-groups based on

    a. Gender, and

    b. Level of Physics studied

2. PCK in Physics among prospective secondary school teachers can be significantly predicted from the select set of institutional and learner related variables.

Methodology

Sample

The study was conducted on a sample of 633 prospective secondary school Physics teachers in Kerala studying in teacher education institutions affiliated with the University of Calicut, Mahatma Gandhi University, Kerala University and Kannur University.

Tools

The tools used for the study were

1. Pedagogical Content Knowledge Test (Ravishanker &Mumthas, 2017)

2. Curricular Experiences Rating Scale (Ravishanker & Mumthas, 2017)

3. Scale on Motivational factors in Science Teaching (Ravishanker & Mumthas, 2017)

Statistical Techniques Used

After the preliminary statistical analysis, the techniques used were.

1. Pearson's product-moment coefficient of correlation

2. Test of significance of difference between correlations

3. Multiple regression analysis

Major Findings

The following are the noteworthy findings related to the study on PCK in Physics among prospective secondary school teachers in Kerala.

1. The study findings revealed that the extent of PCK in Physics among prospective secondary school teachers is meagre. The same trend is repeated in the case of components also. Student teachers' mean scores are nearly half of the maximum score or below half for all three components: Content Knowledge, Pedagogical Knowledge, and Contextual Knowledge. Among the

selected sample, the student teachers who have done post-graduation in Physics have higher PCK in Physics, followed by those who have graduated with Physics as the main subject. The trend is evident from figures 10 and 11.

Figure 10

Mean Percentage Score of PCK in Physics

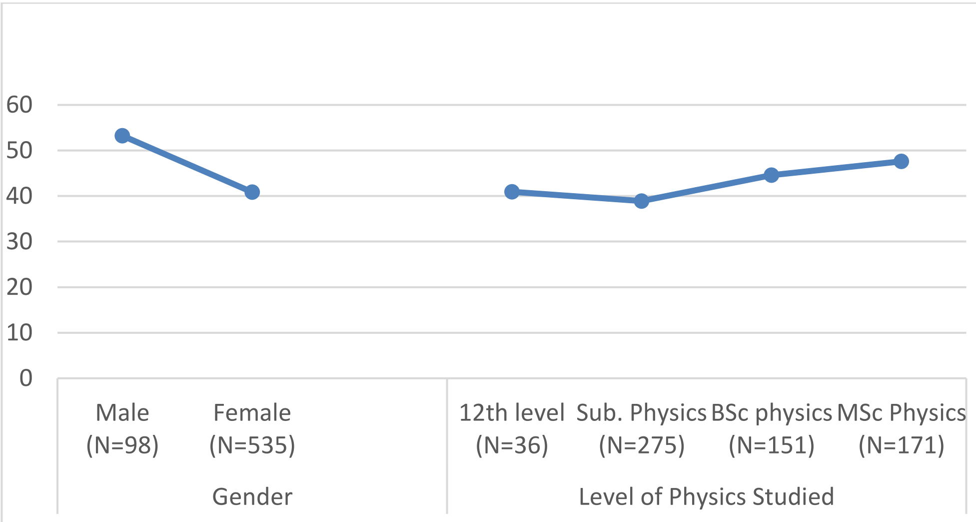
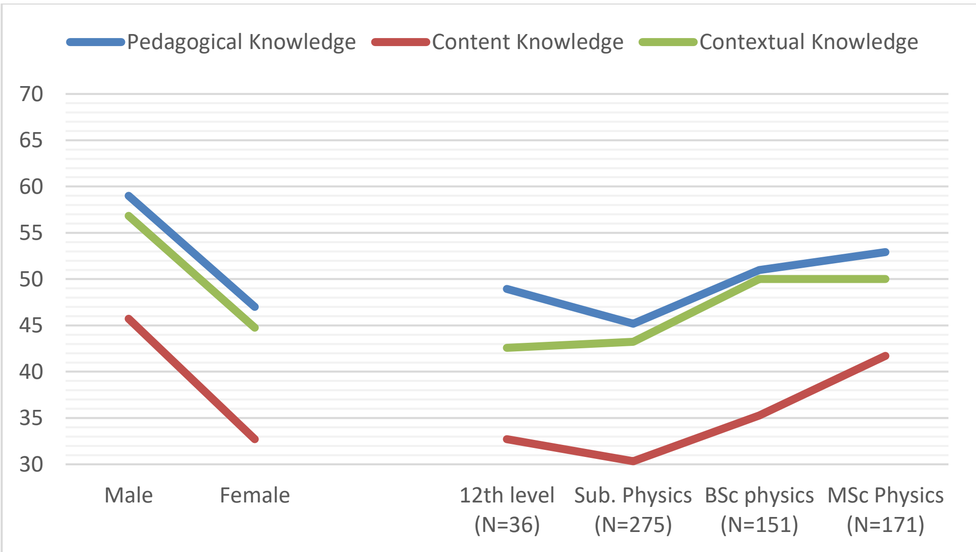


Figure 11

Mean Percentage Score of Components of PCK in Physics (Sub-groups)



2. A significant but low positive correlation exists between each of the select institutional and learner related factors and PCK in Physics among prospective secondary school teachers. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills. Teacher Motivation has the most negligible correlation with prospective secondary school teachers' PCK in Physics.
3. The study findings also revealed that prospective secondary school male teachers have greater PCK in Physics (total and component-wise) than their female counterparts and the difference is significant.
4. The study's findings also revealed a significant and positive correlation between each of the select institutional and learner-related factors and PCK in Physics in the subgroups based on Gender. For female prospective secondary school teachers, the highest correlations are found between the variables Attitude towards Science and PCK in Physics, followed by Opportunity to achieve Learning Objectives and Opportunity to Learn Skills.
5. Accomplishments during School Internship have the most negligible correlation with prospective female secondary school teachers' PCK in Physics.
6. For male prospective secondary school teachers, the highest correlations are found between the variables Pre-Internship Learner Engagement and PCK in Physics, followed by Engagement during School Internship and Attitude towards Science.

7. The correlation between the Role of Teacher Educator and Teacher Motivation is negligible with prospective male secondary school teachers' PCK in Physics.

8. There is a significant gender difference in the extent of the relationship between Pre-Internship Learner Engagement, Engagement during School Internship and Accomplishments during School Internship and PCK in Physics. The relationship between the above three variables and PCK in Physics is higher among male prospective secondary school teachers than their counterparts.

9. A significant and positive correlation exists between Attitude towards Science, Opportunity to achieve Learning Objectives, Self-Efficacy, Teacher Motivation, Engagement during School Internship, Opportunity to Learn Skills, Pre-Internship Learner Engagement and PCK in Physics in the sub-groups who have studied Physics as their main subject for graduation. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learning Objectives and Self-Efficacy. Role of Teacher Educator and Accomplishments during School Internship has no significant relation with PCK in Physics.

10. A significant, positive but low correlation exists between Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Attitude towards Science, Role of Teacher Educator, Accomplishments during School Internship and PCK in Physics in the sub-group who have done post-

graduation in Physics. The highest correlations are found between the variable Pre-Internship Learner Engagement followed by Opportunity to achieve Learning Objectives and Opportunity to achieve Learn Skills. Teacher Motivation has no significant relation with PCK in Physics.

11. A significant positive but low correlation exists only between Select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science, Opportunity to Learn Skills, Opportunity to achieve Learning Objectives, Pre-Internship Learner Engagement and Role of Teacher Educator in the sub-group who have studied Physics only as a subsidiary subject during their graduation. The highest correlations are found between the variable Attitude towards Science followed by Opportunity to achieve Learn Skills and Opportunity to achieve Learning Objectives.

12. A significant positive but low correlation exists only between Select institutional and learner related factors and PCK in Physics for variables viz., Attitude towards Science, Teacher Motivation and Accomplishments during School Internship in the sub-group who have studied Physics only up to class twelfth. The highest correlations are found between the variable Attitude towards Science followed by Teacher Motivation and Accomplishments during School Internship.

13. PCK in Physics (Z') among prospective secondary school teachers can be predicted from three Variables viz., Attitude towards Science (Z_7), Opportunity to Learn Skills (Z_3) and Pre-Internship Learner Engagement (Z_1) using the formula,

$$Z' = .300Z_7 + 0.138Z_3 + 0.118Z_1$$

14. The multiple correlation (R) between the PCK in Physics among prospective secondary school teachers and three significant (predictor) institutional and learner related variables is .438, highly significant with a standard error of 6.95.

15. Prospective secondary school male teacher's PCK in Physics (Z) can be predicted from the Variable Pre-Internship Learner Engagement (Z_1) using the formula,

$$Z' = .320Z_1$$

16. The multiple correlation (R) between the PCK in Physics of prospective secondary school male teachers and predictor variable Pre-Internship Learner Engagement is .320, which is highly significant with a standard error of 7.58.

17. PCK in Physics of prospective secondary school female teachers (Z') can be predicted from two Variables viz., Attitude towards Science (Z_7) and Opportunity to Learn Skills (Z_3) using the formula,

$$Z' = .309Z_7 + 0.149Z_3$$

18. The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) institutional variables is .385, highly significant with a standard error of 6.782.

19. PCK in Physics (Z') of prospective secondary school teachers who have done their graduation with Physics as the main subject can be predicted from the Variable Attitude towards Science (Z_7) using the formula,

$$Z' = .315Z_7$$

20. The multiple correlation (R) between the PCK in Physics of prospective secondary school teachers who graduated with Physics as the main subject and predictor variable Attitude towards Science is .315, highly significant with a standard error of 6.3.

21. PCK in Physics of prospective secondary school teachers who have done their post-graduation in Physics (Z') can be predicted from three Variables viz., Pre-Internship Learner Engagement (Z_1), Engagement during School Internship (Z_4) and Opportunity to Achieve Learning Objectives (Z_2) using the formula,

$$Z' = .192Z_1 + 0.203Z_4 + .226Z_2$$

22. The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) institutional variables is .513, highly significant with a standard error of 7.256.

23. PCK in Physics of prospective secondary school teachers who have done their graduation with Physics as a subsidiary subject (Z') can be predicted from two Variables viz., Attitude towards Science (Z_7) and Opportunity to Learn Skills (Z_3) using the formula,

$$Z' = .345Z_7 + 0.182Z_3$$

24. The multiple correlation (R) between the PCK in Physics of prospective secondary school female teachers and two significant (predictor) institutional variables is .410, highly significant with a standard error of 7.085.

25. PCK in Physics (Z') of prospective secondary school teachers who have studied Physics up to twelfth class can be predicted from the Variable Attitude towards Science (Z_7) using the formula,

$$Z' = .509Z_7$$

26. The study findings revealed the multiple correlation (R) between the PCK in Physics of prospective secondary school teachers who have studied Physics up to twelfth class and predictor variable Pre-Internship Learner Engagement is .509, highly significant with a standard error of 4.084.

Tenability of Hypotheses

1. The first hypothesis states that "a significant relationship exists between select institutional and learner related variables and PCK in Physics".

The coefficient of correlation (Pearson's r) obtained between PCK in Physics and each of the nine variables revealed that all the nine variables have a significant correlation with PCK in Physics. Thus, the first hypothesis is substantiated.

2. The second hypothesis states that "PCK in Physics can be significantly predicted from the select set of variables."

The regression analysis showed that three out of nine institutional and learner related variables, viz., Attitude towards Science, opportunity to Learn Skills and Pre-internship Learner Engagement, are significant predictors of PCK in Physics among prospective secondary school teachers. In the subgroups based on gender, the predictor of PCK in physics among prospective male secondary school teachers is Pre-internship Learner Engagement, and for female candidates, predictors are Attitude towards Science and Opportunity to Learn Skills. In the subgroups based on Level of Physics studied for prospective secondary school teachers who have graduated in physics and those who have studied physics only up to twelfth, the significant predictor is Attitude towards Science. In the case of post-graduates in physics, the significant predictors are Pre-internship Learner Engagement, Engagement during School internship and opportunity to Achieve learning Objectives. Thus, the second hypothesis is substantiated.

CONCLUSION AND RECOMMENDATIONS

The study mainly focused on the prospective secondary school teachers' PCK in Physics. The researcher also studied the relationship between the select institutional and learner related variables and PCK in Physics. The results and findings in the chapter 4 and 5 substantiate the hypotheses of the study and thus the researcher reached into certain conclusions. The conclusion, implications and recommendations for further research related to the study is given in detail in the following sessions of this chapter

Conclusion

Teachers' professional knowledge, which describes the competence in teaching a given subject, has long been recognized as an essential variable for effective teaching (Abell, 2007). This study mainly focused on measuring the Pedagogical Content Knowledge in Physics among prospective secondary school teachers. The study highlights that prospective secondary school teachers lack adequate pedagogical content knowledge in Physics. In the case of components viz., Content Knowledge, Pedagogical Knowledge and Contextual Knowledge also follow the same trend. Knowledge of subject matter, pedagogical knowledge, and Contextual knowledge are crucial components of pedagogical content knowledge and influence the quality of the teaching-learning process. Prospective male teachers have significantly higher PCK in physics than their female counterparts. The prospective teacher's ability to make appropriate connections among Physics concepts, knowledge of scientific procedures, problem-solving ability, and addressing students' difficulties and misconceptions will be affected because of poor PCK. As far as science education in schools is considered, the enhancement in teachers' pedagogical content knowledge leads to better learning among students. The teacher's capacity to choose appropriate situational tasks to illustrate the concepts, reduce misconceptions in the concerned subject, selecting appropriate examples to teach a particular topic etc., is based mainly on the depth of their PCK.

Among the institutional and learner related variable that are expected to influence the PCK in Physics, all selected variables viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science, Self-Efficacy and Teacher Motivation have significant but low correlation with PCK in Physics among prospective secondary school teachers. The correlation shows that PCK in Physics and select variables change together at a constant rate. In the case of male and female prospective teachers Pre-Internship Learner Engagement, Engagement during School Internship and Accomplishments during School Internship has a significant correlation with PCK in Physics. The result reveals that prospective male teachers have higher PCK in Physics than their female counterparts.

Among prospective teachers who have studied Physics as the main subject for graduation, there is a significant but low correlation of PCK in physics with all select institutional and learner related factors except Accomplishments during School

Internship and the Role of Teacher Educator. Higher correlation of Attitude towards Science, Opportunity to Learn Skills and Opportunity to achieve Learning Objectives shows that increasing the possibilities of these variables during teacher education programme will help improve the PCK in Physics.

For prospective teachers with post-graduation in Physics, PCK in Physics has a significant but low correlation with all variables, viz., Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Engagement during School Internship, Accomplishments during School Internship, Role of Teacher Educator, Attitude towards Science and Self-Efficacy. They have higher PCK in Physics than others.

In the case of prospective teachers who have studied only Physics as a subsidiary subject during graduation, Pre-Internship Learner Engagement, Opportunity to achieve Learning Objectives, Opportunity to Learn Skills, Role of Teacher Educator and Attitude towards Science have a higher correlation with their PCK in Physics. For candidates who have studied physics up to twelfth class high, a significant correlation exists between Attitude towards Science, Teacher Motivation, Accomplishments during School Internship and PCK, which shows that experiences from teacher education programme also help in developing PCK in Physics among prospective teachers. Pedagogical content knowledge is viewed on a continuum, with teachers acquiring more of it through appropriate training and experience. Teachers acquire it before they begin teaching, during their pre-service training, and their teaching career. It has to be formulated during teacher preparation through course practices and field experiences to varying degrees during various stages of teacher preparation.

One of the objectives of the study was to test the ability of each select institutional and learner related variable in predicting PCK in Physics among prospective secondary school teachers and identify the significant predictors of PCK in Physics. Multiple regression was used to analyze this. It was found that all the nine institutional and learner related variables have a significant effect and significant correlations with PCK in Physics. But stepwise regression analysis pointed out only three of the nine select institutional and learner related variables as significant predictors of PCK in Physics. These three significant predictors, contributing 19.20 per cent of the variation in the variance of PCK in Physics, are Attitude towards Science (11.90 per cent), Opportunity to Learn Skills (3.70 per cent) and Pre-Internship Learner Engagement (3.60 per cent). In the case of the subgroups based on Gender and Level of Physics studied, the predictor variables were found to be different for each subgroup. In the case of prospective secondary school male teachers, the only significant predictor variable was Pre-Internship Learner Engagement (10.20 per cent). For prospective secondary school female teachers, there were two significant variables contributing 14.9 per cent of the variation in the variance of PCK in physics with contributing variables Attitude towards Science (11.10 per cent) and Opportunity to Learn Skills (3.80 per cent).

For prospective secondary school teachers who graduated in Physics (BSc Physics), ten per cent of whatever makes them differ in their PCK is attributable to differences in Attitude towards Science (9.90 per cent). The remaining 90.1 per cent of the variation in PCK in Physics is attributable to variation in other variables that have not been included in the study. Twenty-six per cent of whatever makes prospective secondary school teachers having post-graduation in Physics differ in their PCK in Physics is attributable to differences in Pre-Internship Learner Engagement, Engagement during School Internship and Opportunity to achieve Learning Objectives. That is, around twenty-six per cent of the variation in PCK in Physics among prospective secondary school teachers having post-graduation in Physics is the contribution of the three predictor variables obtained as predictors in stepwise regression analysis. Seventeen per cent of whatever makes prospective secondary school teachers having studied Physics as a subsidiary subject during graduation differ in their PCK in Physics is attributable to differences in Attitude towards Science and Opportunity to Learn Skills. Around seventeen per cent of the variation in PCK in Physics among prospective secondary school teachers having post-graduation in Physics is the contribution of the two predictor variables obtained as predictors in stepwise regression analysis. Twenty-six per cent of what makes prospective secondary school teachers having graduation in Physics differ in their PCK in Physics is attributable to differences in Attitude towards Science. Around 26 per cent of the variation in PCK in Physics among prospective secondary school teachers who have studied Physics only up to class twelfth is the contribution of the predictor variable obtained as the predictor.

All the findings lead the investigator to conclude that out of nine select institutional and learner related predictor (independent) variables, only three of them viz., Attitude towards Science, Opportunity to Learn Skills and Pre-Internship Learner

Engagement, turned out to be significant predictors of prospective secondary school teachers' PCK in Physics. In the case of subgroups based on Gender and Level of Physics studied, the predictors varied differently.

Educational Implications of the Study

The findings of this study have implications for teacher education with excellent suggestions for modification in the curricular objectives, modes, resources, activities and practices for developing effective school teachers with good PCK. Based on the statistical analysis investigator conclude that PCK in Physics among prospective secondary school teachers is low and the three variables viz., Attitude towards science, opportunity to learn skills, and pre-internship learner engagement are the significant predictors of PCK in Physics.

The implications based on the study are given below.

Pedagogical Content Knowledge be attended

The study's findings show that PCK in Physics among secondary school teachers is low. Hence, teacher preparation should focus on preparing science teachers with the capacity and ability to respond in various ways to instructional needs they face in the process of transforming and representing subject matter to make it comprehensible for the learners. Teacher preparation has to focus on teacher effectiveness and teacher's ability in transforming content into a form easily accessible to learners. The emphasis should be on developing teachers' ability to transform what they know into teaching strategies, which will make knowledge accessible to the learner and make learning fruitful. Pedagogical content knowledge among student teachers will help them deeply understand what all factors in teacher education contribute to professional knowledge. The primary purpose of teacher preparation should be to help prospective teachers integrate knowledge bases in planning for instruction.

Pedagogical content knowledge in teacher education will help in the homogeneous development of content, pedagogical, and contextual knowledge, thus ensuring teacher effectiveness. Fostering PCK in teachers improves their quality and extent of subject matter knowledge and pedagogical skills catering to various learning situations. PCK in teachers will cater amalgamation of teaching skills, pedagogical theory and professional skills, thus creating the proper knowledge, attitude and skills and promoting their holistic development. PCK and teacher effectiveness together will enhance the commitment to the profession, sensitivity to contemporary issues and problems and the level of motivation in teachers. Using PCK as a teacher transformation tool, we can build up a better learning community and strengthen scientific temper. Thus, the teacher empowerment focusing on PCK will help cater to the needs of the milieu.

Subject matter knowledge is the key

Among the three components of PCK selected for the study, content knowledge or subject matter knowledge is low in novice teachers. The study also reveals that student teachers who have post-graduation in physics have higher PCK than other subgroups. Higher PCK among postgraduates in physics aligns with Even (1993), who says an important step in improving teaching should be better subject matter knowledge (SMK) preparation for teachers. The teacher education programmes need to focus on subject matter knowledge. Stronger subject matter education results in greater learning gains in terms of subject matter knowledge and in terms of PCK. There should be enough opportunities for students to explore the nature of the subject and its teaching in the teacher education programme.

Teacher education programmes need to focus on subject matter teaching and pedagogical aspects of teaching. Our teacher education programmes barely give any courses related to subject matter teaching apart from discipline related pedagogy. The analysis of subject matter related to school curriculum based on theories related to PCK will help student teachers develop a variety of representations of the subject matter based upon various instructional contexts. The PCK based approach can help improve student teachers' understanding of the nature of subject matter and peculiarity in the teaching of subject matter with regards to the nature of the discipline. Pedagogical content knowledge of teachers provides clarity on the epistemological basis of the subject, which will help in transmitting the subject into a form accessible to learners. Content knowledge positively affects PCK (Van Driel, De Jong, & Verloop, 2002).

Courses focused on subject-specific pedagogical studies

The domains of pedagogical content knowledge, viz., content knowledge, pedagogical knowledge and contextual knowledge, have a high degree of interaction. Teacher education should focus on the fluidic relationship of all domains and make novice teachers realise that no one domain is different or separate from one another. Colleges of teacher education should incorporate potentially high-value courses, and teaching experiences focused on subject-specific pedagogical studies. Teachers gain much more value from courses and workshops that expose them to subject-specific pedagogy and intensive study of concepts in learning to teach the subject and from actually teaching it with expert mentoring (McDermott & Redish, 1999).

The curriculum, design, structure and organisation of teacher education, and transaction modes, have to be modified according to the need of the hour. Like other professional education programmes, a teacher education curriculum should lead to the development of a sensitive knowledge base for teaching, which in turn will be handy for field applications.

Focus on pre-internship learner engagement

The teacher preparation programme should focus more on student teachers' initial pedagogical beliefs and understand what influenced them in shaping those beliefs. Teacher education programmes should focus the novel ideas in science teaching. The classical and formal pedagogical practices need to be presented comprehensively to help student teachers reshape their existing beliefs for understanding the real art of teaching and learning. This can be articulated by giving novice teachers a detailed picture of alternative perspectives, patterns and practices that are used in teaching and learning. Teacher educators must develop themselves into mentors who can become ideal examples for prospective teachers. Greater emphasis on collaborative learning and group work as a transaction mode will help build trust in student teachers regarding its effectiveness. Teacher education institutions have to be a class of art in terms of digital learning. Ample opportunities for student teachers to use digital platforms and the latest technologies will help develop their confidence and prepare them for the future. Exposure to quality resources and research materials related to classroom teaching and teaching-learning challenges will help mould 21st-century teachers.

Ample opportunities focusing positive attitude, skills and professionalism

Teacher education should focus on relevant attitudes and skills essential for student teachers to perform effectively in their teaching career and equip them with the conceptual and theoretical framework to understand the niceties of the profession. The perception of prospective teachers about the nature of science, its evolution and its importance as a school subject is crucial in becoming an effective science teacher. The teacher education curriculum should focus on science's process and process skills. This will give ample opportunities for learners to shape their approach and behaviour towards the subject. Proper attitude will trigger thinking strategies and subject-specific knowledge in student teachers, which helps them become good facilitators and scaffolders in their careers.

Make the learning objectives precise and useful

The study shows that both the opportunity to achieve learning objectives and learn skills have a significant correlation with PCK. More emphasis on professional aspects of teaching, subject matter teaching and field experiences can help them gain the pedagogical content knowledge and experiences essential for a teacher. Professional aspects related to teaching and learning, that is, knowledge of schools and learners, are critical in shaping a teacher. Educational psychology, educational foundations, multicultural perspectives on teaching and learning and the scope of counselling are elementary in shaping a professional teacher. A clinical approach should be maintained to help student teachers understand and comprehend these areas, which will help them understand the importance of theory in teacher preparation.

The student-teacher has to be developed as a researcher by emphasizing observation of production and development of process skills. Mini research projects using both qualitative and quantitative techniques should be initiated during teacher education programmes where novice teachers investigate the complexities of classroom teaching and learning. Engagement in research about classroom teaching-learning can help shape the prospective teachers' knowledge, skills, and attitude.

Field experiences and internship play a great role

Apart from the pre-internship learner engagement, the study shows that Engagement during school internship and accomplishments during school internship also have a good role in shaping the PCK of prospective teachers. Present teacher education programme fails to cater for the very expectations of student teachers, where they expect they will be told how to teach and instead, they are presented with an enormous number of teaching issues to consider, which readily don't translate into how to conduct a lesson. The primary cause of disappointment among student teachers is that teacher education programmes fail to integrate theory and practice in teaching. The field experiences and internship should focus on integrating theory and practice. Integration of all formal domains of knowledge and knowledge of practice is very much required for successful teaching. The approach of reflective practice and reflection of own teaching has to be made a habit in teachers, which will help them understand their PCK. PCK developed and modified during the field experiences and internship gives the novice teachers real-time experience, which will lead to the proper integration of theory and practice in varied contexts.

The process of learning to teach from personal experiences will be more helpful for student teachers to comprehend the theories of teacher education and will, in turn, build confidence and self-efficacy among them. Learning from experiences will also sensitise prospective teachers about the social, professional and administrative contexts, which is very important for their teaching carrier.

Teachers have to be knowledgeable and motivated to foster their students' growth and development. Professional development programmes for teachers must pay attention to systematically developing pedagogical content knowledge and maintain novice and in-service teachers' intrinsic motivation to foster learning in secondary school students and make it enthusiastic, captivating, and inspiring.

Recommendations for Further Research

Teacher preparation programmes have a lot to do with developing future teachers and equipping them with the knowledge and skills required for effective teaching and mentoring. Efforts regarding future research should be on how we can best produce teachers who are prepared to use their knowledge and skillset for effective learning.

- Comparison of PCK of prospective teachers at the beginning and end of the teacher education programme is recommended. This allows researchers to determine whether the preservice teachers are able to enrich their repertoire of teaching strategies and improve their PCK over the course of the study.

- PCK of a teacher only evolve with time and experience; hence a longitudinal study to find out how the PCK of secondary school teachers progresses over time with experience in the classroom is suggested.

- Future research should focus on all factors that predict the PCK, such as Knowledge of science curricula, student understanding of science, knowledge of instructional strategies, and assessment knowledge. Factor analysis of PCK by incorporating more independent variables that will influence PCK is also possible to understand its real nature.

- A study on 'Analysis of the extent of PCK of pre-service and in-service teachers using an open-ended tool is recommended. Teacher knowledge is considered implicit hence open-ended questions can create contexts based on meaningful classroom interactions and prompt teachers to reason and reflect more meaningfully.

- As the PCK of teachers influences their teaching competency, there may be a strong relationship between the extent of PCK and the learner's conceptual understanding. Hence a study focusing on PCK and its impact on misconceptions in secondary school physics is recommended.

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Appendix A

FAROOK TRAINING COLLEGE

Pedagogical Content Knowledge Test (Draft)

Dr. Mumthas N.S. — Associate Professor

M.P. Ravishanker — Research Scholar

i. Age : .... years

ii. Semester …………………….

Roll No: ………………

iii. Gender: Male/ Female

iv. Name of the University:

v. Name of the institution:

vi. Locale of the Institution:

Rural ☐ Urban ☐

vii. Marital Status : Married ☐

Unmarried ☐ Divorce ☐

viii. Qualification and percentage of mark scored

1. UG <50% ☐

   50% – 80% ☐

   >80% ☐

2. PG <50% ☐

   50% – 80% ☐

   >80% ☐

ix. Discipline of graduation

1. BSc Physics ☐
2. BSc Chemistry ☐
3. Any other ☐

x. Highest level at which you studied Physics as a separate discipline.

1. 12^{th} ☐
2. BSc Physics ☐
3. MSc Physics ☐
4. BSc Chemistry ☐

Instruction

The following questions are based on the content as well as the pedagogy of teaching of physics at secondary level. Each question is followed by four options (a, b, c, d) among which, one is the best answer. Mark your responses for every question in the separate answer sheet given with the test. The result is purely meant for research purpose.

1. Constructivism emphasizes on
    a. The role of imitation
    b. The role of the learner in constructing his own view of the world
    c. memorizing information and testing through recall
    d. dominant role of teacher
2. Kamala took her class for a field trip; coming back she discussed the trip with her students. It may be connoted as
    a. Assessment of learning
    b. Learning of assessment
    c. Assessment for learning
    d. Learning for assessment
3. During a new lesson helping learners to recall what they have learnt earlier is important because
    a. It helps in smooth beginning of classroom instruction
    b. Relating new information to prior knowledge enhances learning
    c. It is an effective way of revising old lessons
    d. It increases the memory of learners.
4. Ms. Shani, Principal of a school wanted to implement an integrated approach to teaching of science rather than teaching different disciplines separately. The basis of this is
    a. Non availability of qualified teachers in her school to teach respective disciplines
    b. Difficulty to adjust the teachers in time table
    c. Difficulty of students to adjust to different teachers
    d. All disciplines are interlinked.
5. Multilingual character of Indian society is
    a. Hindrance in teaching learning process.
    b. A resource for enrichment of social life.
    c. An obstacle in motivating students to learn.

d. A factor that makes school incomprehensible for the learners.

6. While teaching the concept "force can change the shape of an object" to students a teacher plans following activities

   i. Provide a dough on plate and ask the students to press it down with hand

   ii. Explains concepts using commonly observed examples

   iii. Show a multimedia clip explaining the concept with some examples

      a. She wants to exhibit her knowledge.

      b. She likes to use of technology in classes.

      c. She has to prepare students for test.

      d. She addresses the heterogeneity in learners.

7. For creative answers we employ

   a. Direct teaching and direct questions.

   b. Content based questions.

   c. Open ended questions.

   d. Tough questions.

8. During selection of a learning task in order to develop research-oriented skills of students in science class teacher may choose a topic

   a. From the content given in the syllabus/text book.

   b. Which the students in a class find interesting.

   c. Which she thinks is important for the students to know.

   d. Related to problem faced by students in their day-to-day life.

9. Which of the following statements is not a feature of learning?

   a. Learning mediates behavior.

   b. Learning is a resultant of certain experiences.

   c. Study of behavior is learning.

   d. Unlearning is also part of learning.

10. You have a class comprising of students of mixed age groups, knowledge of which among the following will be helpful to you as a teacher

    a. Cultural background

    b. Developmental stages

    c. Occupation of their parents

    d. Socio economic background.

11. Which of the following is not a feature of teaching for understanding?

    a. Ask students to explain a phenomenon or a concept in their own words

b. Teach students to provide examples to illustrate how a law works

c. Help students to see similarities and differences and generate analogies.

d. Enable students to memorise isolated facts and procedures.

12. Learners should not be encouraged to

a. Actively interact with other learners in group work.

b. Ask as many questions as possible both inside or outside the class

c. Memorise all answers to questions which teachers may ask.

d. Participate in as many co-curricular activities as possible.

13. A science teacher plans group activities to teach "properties of air" to his students of class VI. The attribute he would like to have for student to be selected as group leader will be

a. Freedom to choose roles, work at their own pace and understanding

b. Ordering students to take roles and deliver in consonance with their understanding.

c. Giving major roles to brighter students to ensure the group finishes first.

d. Assigning roles as per capability, motivating and coordinating among the group members.

14. During science practical work, boys generally handle apparatus and do experiments meanwhile asking girls to record data or wash utensils. This tendency reflects that

a. Girls being delicate prefer such less energy consuming tasks.

b. Girls are excellent observers and record data flawlessly.

c. Stereotyping of masculine and feminine roles takes place in schools also

d. Boys can handle equipment more efficiently as they are naturally endowed for doing such things.

15. Environment for the science classroom emphasized in National Curriculum Framework-2005 is

a. Conducive for constructivist learning where learners engage in experiential tasks.

b. As an arrangement of teaching strategies.

c. conceptualizing science as a means of discovering theories, laws and principles

d. like a treasure hunt to guess what is there in teacher's mind

16. Practical work is an essential aspect in science teaching and learning-

a. In order to develop scientific knowledge.

b. To differentiate research and laboratory work.

c. As communication not as discovery.

d. To establish link between both the objects and observable phenomena.

17. Primary consideration in lesson planning should be

a. Meeting the needs of all students in the class

b. Creating a conducive classroom environment

c. The curricular goals

d. Providing pupils with work

18. Which of the following statements stands for inclusion of co scholastic areas in the curriculum?

a. Physical, social and emotional developments are interrelated.

b. Co-scholastic activities alleviate the stress caused by routine teaching.

c. Co-scholastic activities remove disparity in students.

d. Co-scholastic activities reduce the workload of teachers.

19. Teachers asking questions to a preferred group of students of their choice in classroom and getting answers. This

a. requires skills to identify students who can answer the questions more often

b. is necessary to keep going in class to cover syllabus

c. deprives other students equal opportunity

d. supports students who take interest and become teachers' choice

20. While teaching, a teacher should reflect on the following facts except

a. understanding of the learning goals

b. compensating the loss of time occurred in sharing learning goals with students

c. devising appropriate method to achieve these goals

d. Designing of assessment to know what students wants to know.

21. Of the following exception for learner control of instruction is

a. Asking learner to memorise the information

b. Asking learner to select information source

c. Asking learner to relate question to objective

d. Asking learner to choose transaction method

22. Which of the following points should be considered by a teacher while preparing an assessment that supports personalisation of learning?

i. plan a common date, time and method of the assessment

ii. Involve students in decision making about assessment and practice,

iii. Provide a range of assessment to ensure inclusivity

a. only(i)and(ii)

b. only (ii) and (iii)

c. only (i) and (iii)

d. (i), (ii) and (iii)

23. Following is a problem from text book of Class VIII: "An aquarium is in the form of a cuboid whose external measures are70 cm x 30 cm x 50 cm. The base, side faces and back faces are to be covered with a coloured paper. Find the area of the paper needed. Which cognitive skill of Bloom's Taxonomy is addressed in this problem?

a. Knowledge

b. Comprehension

c. Synthesis

d. Application

24. Is a vector necessarily changed if it is rotated through an angle?

a. Maybe

b. No

c. Yes

d. Never

25. When somebody asks about component of vector your answer will be, Its

a. Always equal to magnitude.

b. Always less than magnitude.

c. Always greater than its magnitude.

d. Direction of vector.

26. Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single storeyed building at the same instant of time. The time it takes the balls to reach the ground below will be:

a. About half as long for the lighter ball as for the heavier one.

b. About the same for both balls.

c. Considerably less for the heavier ball, but not necessarily half as long.

d. Considerably less for the lighter ball, but not necessarily half as long.

27. The two metal balls of the previous problem roll off a horizontal table with the same speed. In this situation:

a. both balls hit the floor at approximately the same horizontal distance from the base of the table.

b. the lighter ball hits the floor at about half the horizontal distance from the base of the table than does the heavier ball.

c. the heavier ball hits the floor considerably closer to the base of the table than the lighter ball, but not necessarily at half the horizontal distance.

d. the lighter ball hits the floor considerably closer to the base of the table than the heavier ball, but not necessarily at half the horizontal distance.

28. A boy releases a stone from an elevator going up with an acceleration a. He has a doubt about acceleration of stone after release. Select correct answer from following choices.

a. a upward

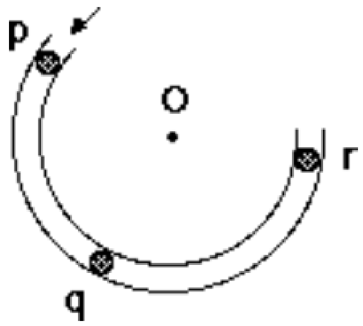
b. (g-a) upwards

c. (g-a) downwards

d. g downward

USE THE STATEMENT AND FIGURE BELOW TO ANSWER THE NEXT TWO QUESTIONS.

The figure below shows a frictionless semicircular channel with center at "O". The channel has been fixed to a frictionless horizontal surface. Forces exerted by the air are negligible. A ball is released at high speed into the channel at "p" and exits at "r.



29. Consider the following distinct forces:

i. A downward force of gravity.

ii. A force exerted by the channel pointing from q to O.

iii. A force in the direction of motion.

iv. A force pointing from O to q.

Which of the above forces is (are) acting on the ball when it is within the frictionless channel at position "q"?

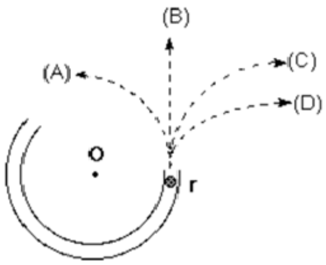
a. i only.

b. i and ii.

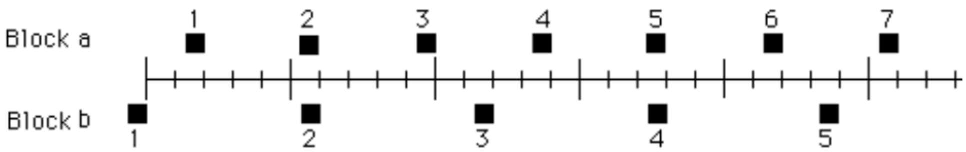
c. i and iii.

d. i, ii, and iii.

30. From the following identify force exerted by a proton on a proton
    i. Gravitational
    ii. Weak
    iii. Nuclear
    iv. Electromagnetic
        a. i only.
        b. i and ii.
        c. i and iii.
        d. i, ii, and iii.
31. Students represents the path of the ball after it exit the channel at ‘r’ as shown below. Which path will the ball closely follow after it exits the channel at "r" and moves across the frictionless table top?

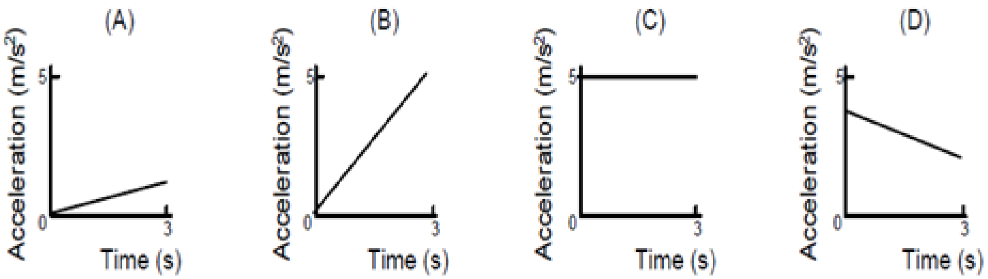


    a. A
    b. B
    c. C
    d. D
32. The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving toward the right.



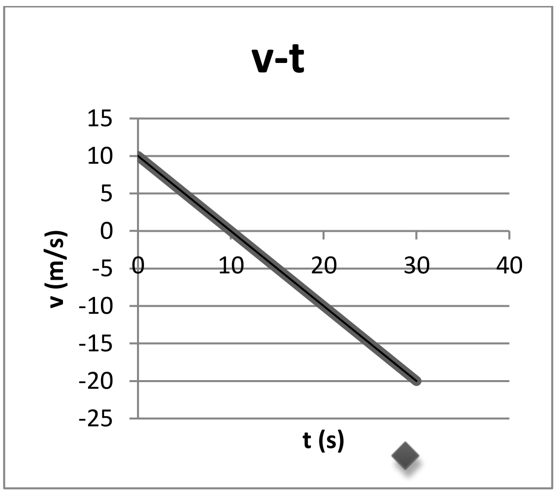
    The accelerations of the blocks are related as follows:
    a. The acceleration of "a" is greater than the acceleration of “b".
    b. The acceleration of "a" equals the acceleration of "b". Both accelerations are greater than zero.
    c. The acceleration of "a" equals the acceleration of "b". Both accelerations are zero.
    d. Not enough information is given to answer the question.

33. Which all statements given by a student are correct regarding motion of a particle?
    i. The magnitude of the velocity of particle is equal to its speed.
    ii. The magnitude of average velocity in an interval is equal to its average speed in that interval
    iii. It is possible to have a situation in which the speed of particle is always zero but average speed is not zero.
    iv. It is possible to have situation in which the speed of particle is never zero but average speed in an interval is zero.
        a. ii, iii & iv
        b. ii & iii
        c. i, ii & iii
        d. i & ii
34. Given below is acceleration versus time graphs of five objects. Which object has the smallest change in velocity during the three second interval?



a. A   b. B   c. C   d. D

35. Figure below is a v-t plot for a particle on a straight line drawn by a class IX student, The particle has



a. constant acceleration.

b. never turned around.

c. zero displacement.

d. average speed in the interval 0 to 10s is same as average speed in the interval 10s t0 20s.

36. Given below are responses of students for a question. A car moving on a horizontal path may have ……….

i. Varying speed without having varying velocity.

ii. Varying velocity without having varying speed.

iii. Non zero acceleration without having varying velocity.

iv. Non zero acceleration without having varying speed.

a. i & ii

b. ii & iv

c. ii & iii

d. i, ii & iv

37. From the given choice which all option defines the Action and reaction in best manner?

i. Act on two different objects.

ii. Have equal magnitude.

iii. Have opposite direction.

iv. Have resultant zero.

a. i, ii & iii

b. ii & iv

c. i & iii

d. all of the above

38. When a horse pull a cart, the force that helps the horse to move forward is force exerted by

a. Cart on the horse.

b. The ground on the horse

c. The ground on the cart

d. The horse on the ground

39. The force exerted by the floor of an elevator on the foot of a person standing there is more than the weight of the person if elevator is

i. Going up and slowing down

ii. Going up and speeding up

iii. Going down and slowing down

iv. Going down and speeding up

a. i & ii

b. ii & iii

c. iii

d. i & iv

40. If the tension in the cable supporting an elevator is equal to weight of the elevator, the elevator may be

i. Going up with increasing speed.

ii. Going down with increasing speed.

iii. Going up with uniform speed.

iv. Going down with uniform speed.

a. i & iv

b. ii & iii

c. ii & iv

d. iii & iv

41. Two cars of unequal masses use similar tyres. If they are moving at the same initial speed, the minimum stopping distance

a. Is smaller for heavier car

b. Is smaller for lighter car

c. Is same for both cars

d. Depends on volume of the car

42. A particle is going in a spiral path with constant speed then

a. Magnitude of acceleration is constant.

b. The velocity of the particle is constant.

c. The acceleration of particle is constant

d. The magnitude of acceleration is decreasing continuously.

43. A man applies a force of constant magnitude perpendicular to the velocity of a particle. Which statement below will be characteristics of the motion of particle in a plane?

a. It moves in a circular path

b. Its velocity is constant

c. Its acceleration is constant

d. its kinetic energy is constant

44. You lift a suitcase from the floor and keep it on a table. The work done by you on the suitcase does not depend on

i. Path taken by the suit case

ii. Time taken by you doing so.

iii. Weight of the suitcase.

iv. Your weight.

a. i & ii

b. ii & iii

c. i & iv

d. iv

45. We say no work is done by a force on object if,

i. The force is always perpendicular to its velocity

ii. The force is always perpendicular to its acceleration

iii. The object is stationary but the point of application of force moves on the object.

iv. Object moves in such a way that point of application of force remain fixed.

a. i, ii & iii

b. i, iii & iv

c. ii, iii & iv

d. i & iv only

46. Consider the following two statements

A. The linear momentum of particle is independent of the frame of reference.

B. The kinetic energy of particle is independent of frame of reference.

a. Both A and B are true

b. A is true B is false

c. A is false but B is true

d. Both A and B are false

47. External forces acting on a system have zero resultant then the centre of mass,

i. Must not move

ii. Must not accelerate

iii. May move

iv. May accelerate

a. i & ii

b. ii & iii

c. iii & iv

d. i & iv

48. A boy throw two balls simultaneously in air, then the acceleration of centre of mass of ball when in air

    a. Depends on the direction of motion of the balls.

    b. Depends on the masses of two balls

    c. Depends on the speeds of the two balls

    d. Is equal to g.

49. The student after have known about collisions asks you what all happens in an elastic collision

    i. Kinetic energy remains constant

    ii. Linear momentum remains constant

    iii. The final K.E is equal to initial K.E

    iv. The final linear momentum is equal to initial linear momentum.

        a. i, ii & iv

        b. ii, iii & iv

        c. i, iii & iv

        d. ii & iii

50. Akhila observes a body moving towards a finite body at rest collide with it, It is possible that

    i. Both bodies come to rest

    ii. Both bodies move after collisions

    iii. The moving body comes to rest and stationary body starts moving

    iv. The stationary body remains stationary; the moving body changes its velocity.

        a. i & ii

        b. i & iii

        c. ii & iii

        d. iii & iv

51. When all external forces acting on a non-rigid body are removed which of the following quantities remain constant?

    i. Angular momentum

    ii. Linear momentum

    iii. K.E

    iv. Moment of inertia

        a. i & ii

b. ii & iii

c. i & iii

d. iii & iv

52. A student pushes a book across a classroom table. Which of the following statements best explains the difference between the amount of force needed to start the book moving and the amount of force needed to keep it moving?

    a. Less force is needed to start the book moving, because there is less friction than when it is already moving

    b. Less force is needed to start the book moving, because there is less potential energy in the table than in the book

    c. More force is needed to start the book moving, because there is more potential energy in the table than in the book.

    d. More force is needed to start the book moving, because there is more friction than when it is already moving.

53. A man is walking forward. What will be direction of frictional force?

    a. Friction acts backwards

    b. Friction acts forward

    c. Friction does not act at all

    d. Friction acts normally

54. A boy finds that a sphere does not roll on a particular surface. We can say it's a

    a. smooth horizontal surface

    b. rough horizontal surface

    c. smooth inclined surface

    d. rough inclined surface

55. A hollow sphere and a solid sphere having same mass and same radii are rolled down a rough inclined plane.

    a. The hollow sphere radius reaches bottom first

    b. The solid sphere reaches bottom with greater speed.

    c. The solid sphere reaches bottom with greater K.E.

    d. Two spheres will reach the bottom with same linear momentum.

56. A sphere is rolled on rough horizontal surface; it gradually slows down and stops. The friction tries to

    i. Decreases linear velocity

    ii. Increases angular velocity

    iii. Increases linear momentum

iv. Decreases the angular velocity

a. i & ii

b. i & iv

c. ii & iv

d. iii & iv

57. If a planet is moving in an elliptical orbit round the sun. The work on the planet by gravitational force of the sun

i. Is zero in any small part of the orbit

ii. Is zero in some parts of the orbit

iii. Is zero in one complete revolution

iv. Is zero in no part of the motion

a. i & iv

b. iii & iv

c. ii & iii

d. only iii

58. Students after discussions reach following conclusions. Select the correct statements

i. A SHM is necessarily periodic

ii. A SHM is necessarily oscillatory

iii. An oscillatory motion is necessarily periodic

iv. A periodic motion is necessarily oscillatory.

a. All are correct

b. Only ii is correct

c. Both i & ii are correct

d. Both iii & iv are correct

59. How can you describe a particle moving in a circular path with uniform speed? Its motion is

a. Periodic

b. Oscillatory

c. Simple harmonic

d. Angular simple harmonic

60. The equations below are responses from students that you got by conducting a test, which all will be true in the case of simple harmonic motion.

i. Maximum P.E= Maximum K.E

ii. Minimum P.E= Minimum K.E

iii. Minimum P.E= Maximum K.E

iv. Maximum K.E= Minimum K.E

a. i & ii

b. ii & iii

c. only iii

d. iii and iv

61. Of the following apparatuses which of them will change period as they are taken to moon.

i. A simple pendulum

ii. A physical pendulum

iii. A torsional pendulum

iv. A spring mass system

a. Both i and ii

b. Only i

c. Both iii and iv

d. Only ii

62. Bernoulli theorem is based on conservation of

a. Momentum

b. Mass

c. Energy

d. Angular momentum

63. A child completely immerses a stone in a liquid. Of the following statements which all is true about force exerted by liquid on stone.

i. Increase if it is pushed deeper inside the liquid.

ii. Change if its orientation is changed

iii. Decrease if it is taken partially out of the liquid

iv. Be in the vertically upward direction

a. Only i

b. ii & iii

c. only iii

d. iii & iv

64. Raju puts a small hole near the bottom of an open tank filled with a liquid. The speed of the water ejected does not depend on

i. Area of the hole
ii. Density of the liquid
iii. Height of liquid from hole
iv. Acceleration due to gravity
   a. Both i & ii
   b. Only i
   c. Both iii & iv
   d. Only ii

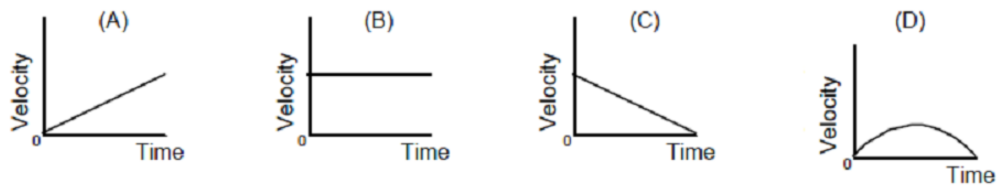
65. When Sunil pushes more air in a soap bubble, he finds that pressure in it
   a. Decreases
   b. Increases
   c. Remain same
   d. Becomes zero

66. Of the following below which all are responsible for rise of liquid in a capillary tube
   i. The material
   ii. The length
   iii. The outer radius
   iv. The inner radius of the hole.
      a. All of the above
      b. ii, iii & iv
      c. i, ii & iv
      d. iii & iv only

67. Teacher teaching length measurement in a class for first time ask student to use an eraser then a pencil to measure the length and breadth of notebook. What would have made her to choose pencil and eraser rather than directly using a ruler/scale for measurement?
   i. To make students aware of need and advantage of standard units
   ii. To understand what measurement means and is
   iii. To enable to choose most appropriate object or unit to measure length
   iv. To keep students engaged in class and motivate them to learn.
      a. Only i & ii
      b. i, ii & iii
      c. iii & iv

d. only iv

68. Given below are velocity-time graphs of 4 objects. All axes have same scale. Which among the four represents greatest change in position during the interval?



a. A

b. B

c. C

d. D

69. If you have to teach the following topics in class ix, which order will you teach them to enhance existing knowledge of your students.

i. Motion

ii. Gravitation

iii. energy

iv. Light

v. Newton's laws of motion

vi. Power

vii. Work

a. i, ii, iii, iv, v, vi, vi

b. i, iii, v, vi, ii, iv, vii

c. i, v, ii, iii, vii, vi, iv

d. v, i, ii, iii, vii, vi, iv

70. Instead of the graph shown below

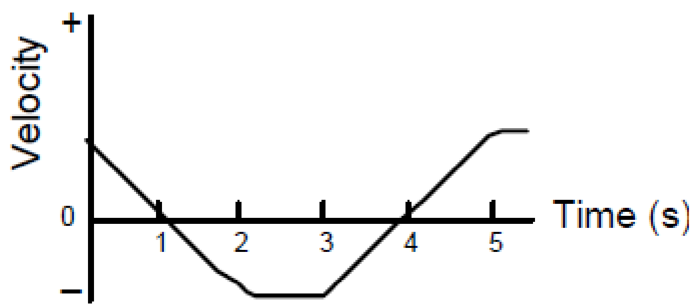


FIGURE 1

Appendix

Three students Sarala, Hima and Shan redraw Figure 1 as Shown in Figures 2 ,3, 4 respectively.

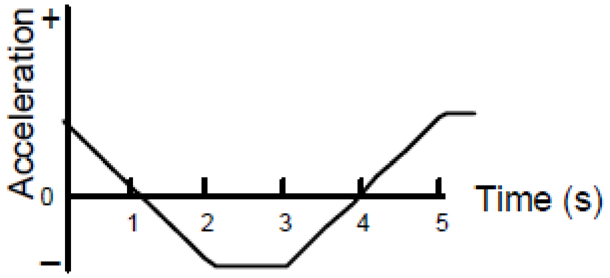


FIGURE 2

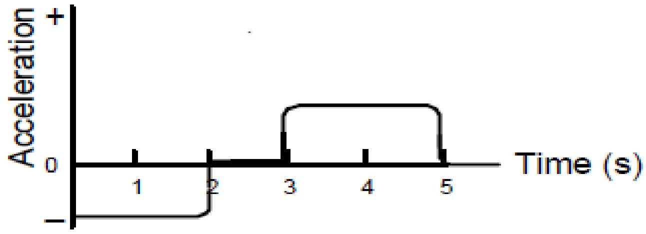


FIGURE 3

FIGURE 4

Whose figure is correct?

a. Sarala

b. Hima

c. Shan

d. Both Hima and Shan

Appendix

Response Sheet of PCK Test

1	a	b	c	d
2	a	b	c	d
3	a	b	c	d
4	a	b	c	d
5	a	b	c	d
6	a	b	c	d
7	a	b	c	d
8	a	b	c	d
9	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d
21	a	b	c	d
22	a	b	c	d
23	a	b	c	d
24	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d
31	a	b	c	d
32	a	b	c	d
33	a	b	c	d
34	a	b	c	d
35	a	b	c	d

36	a	b	c	d
37	a	b	c	d
38	a	b	c	d
39	a	b	c	d
40	a	b	c	d
41	a	b	c	d
42	a	b	c	d
43	a	b	c	d
44	a	b	c	d
45	a	b	c	d
46	a	b	c	d
47	a	b	c	d
48	a	b	c	d
49	a	b	c	d
50	a	b	c	d
51	a	b	c	d
52	a	b	c	d
53	a	b	c	d
54	a	b	c	d
55	a	b	c	d
56	a	b	c	d
57	a	b	c	d
58	a	b	c	d
59	a	b	c	d
60	a	b	c	d
61	a	b	c	d
62	a	b	c	d
63	a	b	c	d
64	a	b	c	d
65	a	b	c	d
66	a	b	c	d
67	a	b	c	d
68	a	b	c	d
69	a	b	c	d
70	a	b	c	d

Appendix

Scoring Key of PCK Test

1	b		36	b
2	c		37	d
3	d		38	b
4	d		39	b
5	b		40	d
6	d		41	c
7	c		42	a
8	d		43	a
9	c		44	a
10	b		45	b
11	d		46	d
12	c		47	b
13	d		48	d
14	c		49	b
15	a		50	c
16	d		51	a
17	c		52	b
18	a		53	d
19	c		54	c
20	d		55	b
21	a		56	a
22	a		57	c
23	d		58	c
24	c		59	a
25	a		60	a
26	b		61	a
27	c		62	c
28	d		63	d
29	b		64	a
30	b		65	a
31	b		66	c
32	d		67	b
33	a		68	b
34	a		69	c
35	a		70	b

Appendix B

FAROOK TRAINING COLLEGE

Pedagogical Content Knowledge Test (Final)

Dr. Mumthas N.S. — Associate Professor

M.P. Ravishanker — Research Scholar

i. Age : .... years

ii. Semester …………………….

Roll No: ………………

iii. Gender: Male/ Female

iv. Name of the University:

v. Name of the institution:

vi. Locale of the Institution:

Rural ☐ Urban ☐

vii. Marital Status : Married ☐

Unmarried ☐ Divorce ☐

viii. Qualification and percentage of mark scored

1. UG <50% ☐

   50% – 80% ☐

   >80% ☐

2. PG <50% ☐

   50% – 80% ☐

   >80% ☐

ix. Discipline of graduation

1. BSc Physics ☐
2. BSc Chemistry ☐
3. Any other ☐

x. Highest level at which you studied Physics as a separate discipline.

1. 12^{th} ☐
2. BSc Physics ☐
3. MSc Physics ☐
4. BSc Chemistry ☐

Instruction

The following questions are based on the content and the pedagogy of teaching physics at the secondary level. Each question is followed by four options (a, b, c, d). Find out the best answer—Mark your responses for every question in the separate answer sheet given with the test. The result is purely meant for research purposes.

1. Constructivism emphasises on
   a. The role of imitation
   b. The role of the learner in constructing his own view of the world
   c. Memorising information and testing through recall
   d. the dominant role of the teacher
2. Kamala took her class on a field trip; coming back she discussed the trip with her students. It may be connoted as
   a. Assessment of learning
   b. Learning of assessment
   c. Assessment for learning
   d. Learning for assessment
3. Ms. Shani, the Principal of a school, wanted to implement an integrated approach to science teaching rather than teaching different disciplines separately. The basis of this is
   a. Non-availability of qualified teachers in her school to teach respective disciplines
   b. Difficulty to adjust the teachers on time table
   c. The difficulty of students to adjust to different teachers
   d. All disciplines are interlinked.
4. Multilingual character of Indian society is
   a. Hindrance in teaching learning process.
   b. A resource for enrichment of social life.
   c. An obstacle in motivating students to learn.
   d. A factor that makes school incomprehensible for the learners.
5. During the selection of a learning task to develop research-oriented skills of students in science class teacher may choose a topic
   a. From the content given in the syllabus/textbook.
   b. Which the students in a class find interesting.
   c. Which she thinks is important for the students to know.
   d. Related to problem faced by students in their day-to-day life.

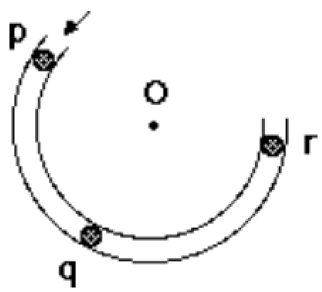
6. Which of the following statements is not a feature of learning?
   a. Learning mediates behaviour.
   b. Learning is a resultant of certain experiences.
   c. The study of behaviour is learning.
   d. Unlearning is also part of learning.
7. You have a class comprising of students of mixed age groups, knowledge of which among the following will be helpful to you as a teacher
   a. Cultural background
   b. Developmental stages
   c. Occupation of their parents
   d. Socio-economic background.
8. Which of the following is not a feature of teaching for understanding
   a. Ask students to explain a phenomenon or a concept in their own words
   b. Teach students to provide examples to illustrate how law works
   c. Help students see similarities and differences and generate analogies.
   d. Enable students to memorise isolated facts and procedures.
9. During science practicals, boys generally handle apparatus and do experiments meanwhile asking girls to record data or wash utensils. This tendency reflects that
   a. Girls being delicate, prefer such less energy-consuming tasks.
   b. Girls are excellent observers and record data flawlessly.
   c. Stereotyping of masculine and feminine roles takes place in schools also
   d. Boys can handle equipment more efficiently as they are naturally endowed for doing such things.
10. The environment for the science classroom emphasised in National Curriculum Framework-2005 is
    a. Conducive for constructivist learning where learners engage in experiential tasks.
    b. As an arrangement of teaching strategies.
    c. conceptualising science as a means of discovering theories, laws and principles
    d. like a treasure hunt to guess what is there in a teacher's mind
11. Practical work is an essential aspect in science teaching and learning-
    a. To develop scientific knowledge.
    b. To differentiate research and laboratory work.
    c. As communication not as discovery.
    d. To establish a link between both the objects and observable phenomena.

12. Which of the following statements stands for inclusion of co scholastic areas in the curriculum?
    a. Physical, social and emotional developments are interrelated.
    b. Co-scholastic activities alleviate the stress caused by routine teaching.
    c. Co-scholastic activities remove disparity in students.
    d. Co-scholastic activities reduce the workload of teachers.
13. Teachers asking questions to a preferred group of students of their choice in the classroom and getting answers. This
    a. requires skills to identify students who can answer the questions more often
    b. is necessary to keep going in class to cover syllabus
    c. deprives other students of equal opportunity
    d. supports students who take an interest and become teacher's choice
14. Of the following, the exception for learner control of instruction is
    a. Asking the learner to memorise the information
    b. Asking learner to select information source
    c. Asking learner to relate the question to objective
    d. Asking learner to choose transaction method
15. Which of the following points should a teacher consider while preparing an assessment that supports the personalisation of learning?
    i. plan a common date, time and method of the assessment
    ii. Involve students in decision making about assessment and practice,
    iii. Provide a range of assessments to ensure inclusivity
        b. only(i)and(ii)
        b. only (ii) and (iii)
        c. only (i) and (iii)
        d. (i), (ii) and (iii)
16. Following is a problem from the textbook of Class VIII: "An aquarium is in the form of a cuboid whose external measures are70 cm x 30 cm x 50 cm. The base, side faces and back faces are to be covered with coloured paper. Find the area of the paper needed. Which cognitive skill of Bloom's Taxonomy is addressed in this problem?
    a. Knowledge
    b. Comprehension
    c. Synthesis
    d. Application

17. Is a vector necessarily changed if it is rotated through an angle?
    a. Maybe
    b. No
    c. Yes
    d. Never
18. When somebody asks about the component of the vector, your answer will be, Its
    a. Always equal to magnitude.
    b. Always less than magnitude.
    c. Always greater than its magnitude.
    d. Direction of vector.
19. Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single-storeyed building at the same instant of time. The time it takes the balls to reach the ground below will be:
    a. About half as long for the lighter ball as for the heavier one.
    b. About the same for both balls.
    c. Considerably less for the heavier ball, but not necessarily half as long.
    d. Considerably less for the lighter ball, but not necessarily half as long.
20. A boy releases a stone from an elevator going up with an acceleration a. He has a doubt about the acceleration of stone after release. Select the correct answer from the following choices.
    a. a upwards
    b. (g-a) upwards
    c. (g-a) downwards
    d. g downward

USE THE STATEMENT AND FIGURE BELOW TO ANSWER THE NEXT TWO QUESTIONS.

The figure below shows a frictionless semicircular channel with center at "O". The channel has been fixed to a frictionless horizontal surface. Forces exerted by the air are negligible. A ball is released at high speed into the channel at "p" and exits at "r.



21. Consider the following distinct forces:

    i. A downward force of gravity.

    ii. A force exerted by the channel pointing from q to O.

    iii. A force in the direction of motion.

    iv. A force pointing from O to q.

    Which of the above forces is (are) acting on the ball when it is within the frictionless channel at position "q"?

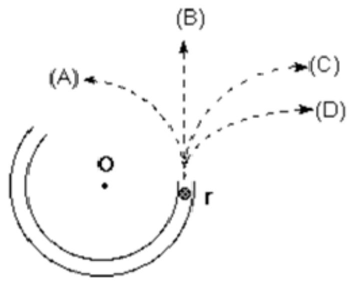
    a. i only.

    b. i and ii.

    c. i and iii.

    d. i, ii, and iii.

22. As shown below, students represent the ball's path after it exits the channel at 'r'. After it exits the channel at "r" and moves across the frictionless table top, which path will the ball closely follow?



    a. A

    b. B

    c. C

    d. D

23. Which statements given by a student are correct regarding the motion of a particle?

    i. The magnitude of the velocity of a particle is equal to its speed.

    ii. The magnitude of average velocity in an interval is equal to its average speed in that interval

    iii. It is possible to have a situation in which particle speed is always zero, but the average speed is not zero.

    iv. It is possible to have a situation in which the particle's speed is never zero, but the average speed in an interval is zero.

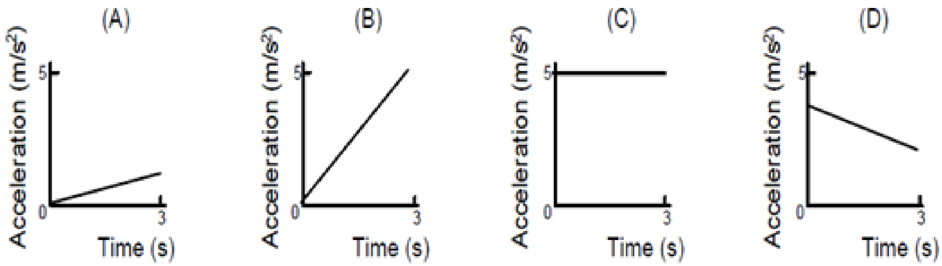
    a. ii, iii & iv

    b. ii & iii

    c. i, ii & iii

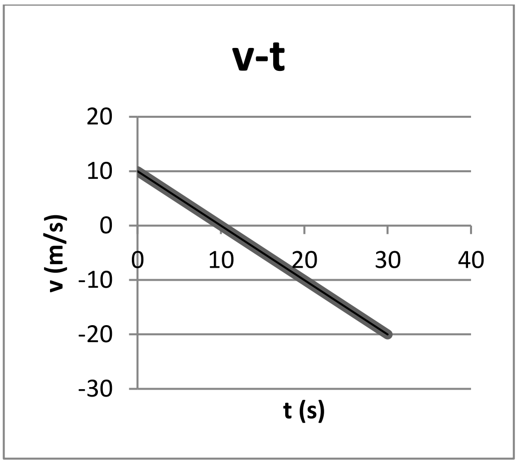
    d. i & ii

24. Given below are acceleration versus time graphs of five objects. Which object has the slightest change in velocity during the three-second interval?



b. A b. B c. C d. D

25. The figure below is a v-t plot for a particle on a straight line drawn by a class IX student. The particle has



a. Constant acceleration.
b. Never turned around.
c. Zero displacement.
d. The average speed in the interval 0 to 10s is the same as in the interval 10s t0 20s.

26. Given below are the responses of students to a question. A car moving on a horizontal path may have ……….

i. Varying speed without having varying velocity.
ii. Varying velocity without having varying speed.
iii. Non zero acceleration without having varying velocity.
iv. Non zero acceleration without having varying speed.

a. i & ii
b. ii & iv
c. ii & iii
d. i, ii & iv

27. When a horse pulls a cart, the force that helps the horse to move forward is force exerted by

    a. Cart on the horse.

    b. The ground on the horse

    c. The ground on the cart

    d. The horse on the ground

28. The force exerted by the floor of an elevator on the foot of a person standing there is more than the weight of the person if elevator is

    i. Going up and slowing down

    ii. Going up and speeding up

    iii. Going down and slowing down

    iv. Going down and speeding up

        a. i & ii

        b. ii & iii

        c. iii

        d. i & iv

29. If the tension in the cable supporting an elevator is equal to the weight of the elevator, the elevator maybe

    i. Going up with increasing speed.

    ii. Going down with increasing speed.

    iii. Going up with uniform speed.

    iv. Going down with uniform speed.

        a. i & iv

        b. ii & iii

        c. ii & iv

        d. iii & iv

30. A man applies a force of constant magnitude perpendicular to the velocity of a particle. Which statement below will be characteristics of particle's motion in a plane?

    a. It moves in a circular path

    b. Its velocity is constant

    c. Its acceleration is constant

    d. its kinetic energy is constant

31. You lift a suitcase from the floor and keep it on a table. The work done by you on the suitcase does not depend on

    i. Path taken by the suit case

ii. Time taken by you doing so.

iii. Weight of the suitcase.

iv. Your weight.

a. i & ii

b. ii & iii

c. i & iv

d. iv

32. Consider the following two statements

A. The linear momentum of a particle is independent of the frame of reference.

B. The kinetic energy of a particle is independent of the frame of reference.

a. Both A and B are true

b. A is true B is false

c. A is false but B is true

d. Both A and B are false

33. A boy throws two balls simultaneously in the air, then the acceleration of the centre of mass of the ball when in the air

a. Depends on the direction of motion of the balls.

b. Depends on the masses of the two balls

c. Depends on the speeds of the two balls

d. Is equal to g.

34. A student pushes a book across a classroom table. Which of the following statements best explains the difference between the amount of force needed to start the book moving and the amount of force needed to keep it moving?

a. Less force is needed to start the book moving because there is less friction than when it is already moving

b. Less force is needed to start the book moving because there is less potential energy in the table than in the book

c. More force is needed to start the book moving because there is more potential energy in the table than in the book.

d. More force is needed to start the book moving because there is more friction than when it is already moving.

35. A man is walking forward. What will be the direction of frictional force?

a. Friction acts backwards

b. Friction acts forward

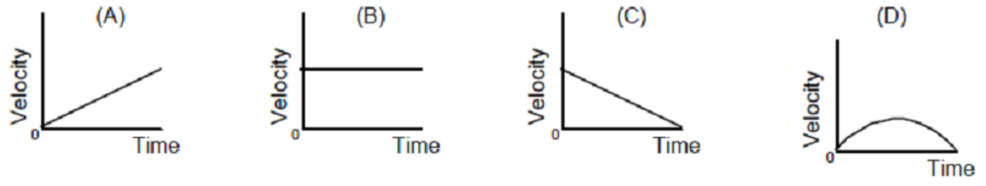
c. Friction does not act at all

d. Friction acts normally

36. A boy finds that a sphere does not roll on a particular surface. We can say it's a
    a. smooth horizontal surface
    b. rough horizontal surface
    c. smooth inclined surface
    d. rough inclined surface
37. A hollow sphere and a solid sphere with the same mass and radii are rolled down a rough inclined plane.
    a. The hollow sphere radius reaches the bottom first
    b. The solid sphere reaches the bottom with greater speed.
    c. The solid sphere reaches the bottom with greater K.E.
    d. Two spheres will reach the bottom with the same linear momentum.
38. If a planet is moving in an elliptical orbit around the sun. The work on the planet by the gravitational force of the sun
    i. Is zero in any small part of the orbit
    ii. Is zero in some parts of the orbit
    iii. Is zero in one complete revolution
    iv. Is zero in no part of the motion
        a. i & iv
        b. iii & iv
        c. ii & iii
        d. only iii
39. The equations below are responses from students that you got by conducting a test, which all will be true in the case of simple harmonic motion.
    i. Maximum P.E= Maximum K.E
    ii. Minimum P.E= Minimum K.E
    iii. Minimum P.E= Maximum K.E
    iv. Maximum K.E= Minimum K.E
        a. i & ii
        b. ii & iii
        c. only iii
        d. iii and iv
40. Bernoulli theorem is based on the conservation of
    a. Momentum
    b. Mass
    c. Energy
    d. Angular momentum

41. A child completely immerses a stone in a liquid, of the following statements, which are all true about the force exerted by the liquid on the stone.
    i. Increase if it is pushed deeper inside the liquid.
    ii. Change if its orientation is changed
    iii. Decrease if it is taken partially out of the liquid
    iv. Be in the vertically upward direction
        a. Only i
        b. ii & iii
        c. only iii
        d. iii & iv
42. Raju puts a small hole near the bottom of an open tank filled with liquid. The speed of the water ejected does not depend on
    i. Area of the hole
    ii. The density of the liquid
    iii. Height of liquid from the hole
    iv. Acceleration due to gravity
        a. Both i & ii
        b. Only i
        c. Both iii & iv
        d. Only ii
43. Teacher teaching length measurement in a class for the first time, ask the student to use an eraser and then a pencil to measure the length and breadth of the notebook. What would have made her choose a pencil and eraser rather than directly using a ruler/scale for measurement?
    i. To make students aware of the need and advantages of standard units
    ii. To understand what measurement means and is
    iii. To enable to choose the most appropriate object or unit to measure the length
    iv. To keep students engaged in class and motivate them to learn.
        a. Only i & ii
        b. i, ii & iii
        c. iii & iv
        d. only iv

44. Given below are velocity-time graphs of 4 objects. All axes have the same scale. Which among the four represents the greatest change in position during the interval?



a. A

b. B

c. C

d. D

45. If you have to teach the following topics in class ix, which order will you teach them to enhance existing knowledge of your students.

i. Motion

ii. Gravitation

iii. energy

iv. Light

v. Newton's laws of motion

vi. Power

vii. Work

a. i, ii, iii, iv, v, vi, vi

b. i, iii, v, vi, ii, iv, vii

c. i, v, ii, iii, vii, vi, iv

d. v, i, ii, iii, vii, vi, iv

46. Instead of the graph shown below

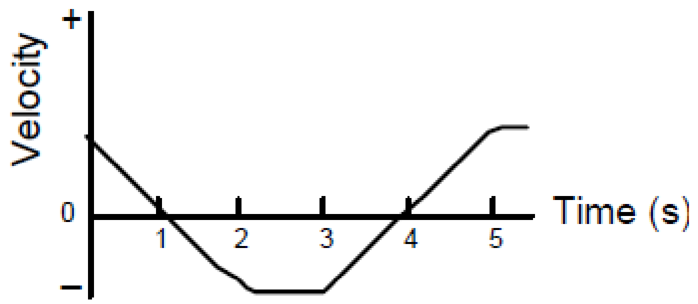


FIGURE 1

Three students, Sarala, Hima and Shan, redraw the Figure 1 as shown in Figures 2,3, and 4.

Appendix

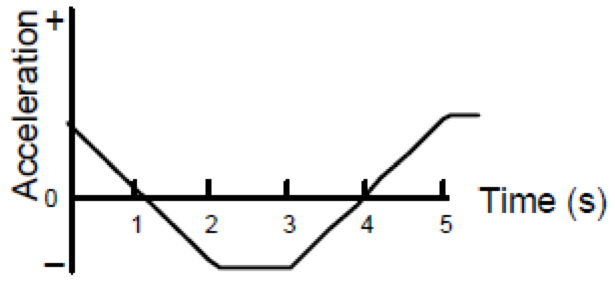


FIGURE 2

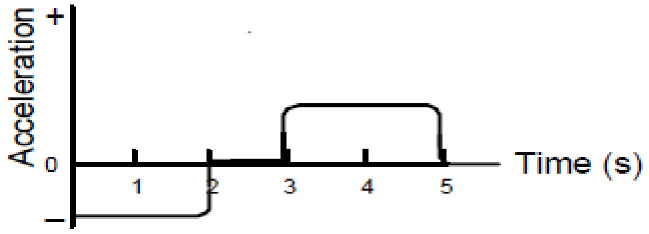


FIGURE 3

FIGURE 4

Whose figure is correct?

a. Saralar

b. Hima

c. Shan

d. Both Hima and Shan

Appendix

RESPONSE SHEET OF PCK TEST

1	a	b	c	d
2	a	b	c	d
3	a	b	c	d
4	a	b	c	d
5	a	b	c	d
6	a	b	c	d
7	a	b	c	d
8	a	b	c	d
9	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d
21	a	b	c	d
22	a	b	c	d
23	a	b	c	d

24	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d
31	a	b	c	d
32	a	b	c	d
33	a	b	c	d
34	a	b	c	d
35	a	b	c	d
36	a	b	c	d
37	a	b	c	d
38	a	b	c	d
39	a	b	c	d
40	a	b	c	d
41	a	b	c	d
42	a	b	c	d
43	a	b	c	d
44	a	b	c	d
45	a	b	c	d
46	a	b	c	d

Appendix

Scoring Key of PCK Test

1	b
2	c
3	d
4	b
5	d
6	c
7	b
8	d
9	c
10	a
11	d
12	a
13	c
14	a
15	b
16	d
17	c
18	a
19	b
20	d
21	b
22	a
23	a

24	a
25	a
26	b
27	b
28	b
29	b
30	a
31	a
32	d
33	d
34	b
35	b
36	c
37	b
38	c
39	a
40	c
41	d
42	a
43	b
44	b
45	c
46	b

Appendix C

FAROOK TRAINING COLLEGE

Curricular Experiences Rating Scale (Final)

Dr. Mumthas N.S. — **M.P. Ravishanker**

Associate Professor — Research Scholar

Roll No.:

Name of the Institution:

Part A

Instruction

The following items are related to your extent of engagement in various aspects during B.Ed course. Each item has five options viz., **often, intermittently, occasionally, rarely and never**. Read each item carefully and mark your response in the appropriate column by putting a tick (✓) mark against each item.

The information will be kept secret and used only for research purpose.

I. Following statements are about the work done by you during B.Ed course. How frequently did you do the following things?

	Pre-Internship Learner Engagement	Often	Intermittently	Occasionally	Rarely	Never
How frequently you…..?	5. Ask doubts and questions during class.					
	6. Discuss novel ideas in physics teaching					
	7. Do a project on science education and its challenges					
	8. Follow the method demonstrated by teacher educators in classes					
	9. Listen to lectures					
	10. Observe and follow demonstrations and examples of teaching					
	11. Make teaching aids and models					
	12. Participate in whole-class discussions and debates					
	13. Participate in group works					
	14. Practice teaching with peers					

Appendix

	Pre-Internship Learner Engagement	Often	Intermittently	Occasionally	Rarely	Never
	15. Prepare assignments on science education and its challenges					
	16. Read about research works in science teaching and science education					
	17. Take classes and do presentation to whole class					
	18. Use computers and other technology in teaching.					

II. The given statements are related to learning objectives that a trainee has to achieve during B.Ed course. How frequently did you get opportunities to participate in the following activities?

	Learning Objectives	Often	Intermittently	Occasionally	Rarely	Never
How frequently do you get opportunities…….?	19. To take a lesson on a new topic in class					
	20. To practice the different skills of teaching with peers					
	21. To accommodate a wide range of skills in a lesson					
	22. To analyse the lessons based on the national and state curriculum framework					
	23. To work on the school content and do pedagogic analysis					
	24. To create specific learning experiences for students					
	25. To discuss learning objectives and learning outcomes of lessons					
	26. To plan lessons by emphasising the process of science					
	27. To develop puzzles, stories and learning activities to motivate students to learn topics					

Appendix

	Learning Objectives	Often	Intermittently	Occasionally	Rarely	Never
	28. To construct learning aids, models and charts to strengthen learning in students					
	29. To practice teaching lessons to a class of full strength in an actual situation during the course					
	30. To construct improvised learning aids and models from locally available materials					
	31. To reflect on the lessons taken by self and peers					
	32. To collect curricular materials and teaching resources					
	33. To understand and use student's misconceptions while planning lessons					
	34. To explore the nature of science					
	35. To integrate topics with the world around the child					
	36. To make use of ICT as an opportunity equaliser					
	37. To explore possibilities to cater to multiple abilities of the child					
	38. To connect the lessons with real-life situations of learners					
	39. To consider science as an integrated discipline					
	40. To make the science lessons life related					
	41. To use assessment as a means to strengthen learning rather than just grading					
	42. To give feedback based on an effective assessment to strengthen learning					
	43. To make use of classroom assessment as a tool for self-evaluation and reflection					
	44. To use standardised assessment to make decisions on how to teach					

III. Given below are the skills a teacher needs to develop in general. During the teacher education program how often you got opportunities to learn to do the following.

	Skills	Often	Intermittently	Occasionally	Rarely	Never
How frequently you got opportunities to learn………?	45. Special strategies to teach exceptional children					
	46. To teach exceptional children					
	47. Cater for the diverse cultural background of students in a class.					
	48. To engage and teach students from poor socioeconomic backgrounds.					
	49. To develop standards and values to reflect your teaching.					
	50. Professionalism in teaching.					
	51. Understand your learning needs and learn how to teach physics.					
	52. Method and strategy to enhance the self esteem of learner.					
	53. From experienced and expert teachers.					
	54. To understand and practice ethical standards and code of conduct for teachers					
	55. Know and participate in existing school practices					
	56. To research problems faced by teachers in the teaching-learning process					
	57. To improve knowledge and practice in teaching					

IV. Below are tasks that a trainee has to fulfil in schools as part of their internship program. During your school internship, how often you did do the following.

	Engagement during Scholl Internship	Often	Intermittently	Occasionally	Rarely	Never
How often you could….?	58. Follow and observe the methods and theories I studied in my Institution.					
	59. Practice the teaching as I learned during my B.Ed course					
	60. Complete all tasks during the lessons as learned in B.Ed course.					
	61. Do all types of assessments and reflection to improve the learning of learners.					
	62. Reflect upon the lessons to improve your teaching					
	63. Participate in the programs of the schools other than classroom teaching					
	64. Conduct research on educational problems and learning difficulties as mentioned in the course					
	65. Implement teaching method learned as part of B.Ed					
	66. Apply the Planning as practised from the training college.					

V. Below are things that you had to accomplish during your school internship program. How frequently were you able to accomplish each of the following?

	Accomplishments during School Internship	Often	Intermittently	Occasionally	Rarely	Never
How often you could........?	67. Fulfil mentor's expectations during the internship program.					
	68. Demonstrate to mentor in school that I could teach according to lesson plan					
	69. Follow the method of teaching studied and planned from college during school internship					
	70. Practice approaches and methods that I learned as part of B.Ed					
	71. Successfully implement the ideas and strategies learned as part of my B.Ed course during internship.					
	72. Improve teaching methods from the mentor's feedback					
	73. Get feedback from mentor after each class					
	70 Get mentor's valuable support to understand the students.					
	71. Develop both content knowledge and pedagogical knowledge with the help of school mentors.					

VI. Evaluate the role of teacher educator and his or her competency in preparing you as secondary school physics teacher.

	Role of teacher educator	Often	Intermittently	Occasionally	Rarely	Never
How frequently did the teacher educator……….?	72. Demonstrate good skills of teaching					
	73. Use evaluation in the most suitable way to give feedback to trainees.					
	74. Conduct practicals and involves in a constructive manner.					
	75. Make sure all trainees get opportunities to teach using all facilities.					
	76. Make trainees aware of the latest research in the area of teaching.					
	77. Support trainees to evolve into well-equipped teachers.					
	78. Good at using and handling ICT and other technologies in the classroom.					
	79. Communicate the ideas in the most understandable and straightforward way					
	80. Help to improve your approach in classroom teaching through their visit and feedback.					

Appendix D

FAROOK TRAINING COLLEGE

Scale on Motivational Factors in Science Teaching (Final)

Dr Mumthas N.S. — Associate Professor

M.P. Ravishanker — Research Scholar

Roll No.:

Name of the Institution:

Instruction

This tool is meant for measuring your attitude towards science, self-efficacy and extent of teacher motivation. Give your response to each statement in a continuum of five-point options, from **strongly agree** to **strongly disagree**.

I. Scale of Attitude towards Science

	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1. Experiments are the best means to acquire knowledge than narration.					
2. Every phenomenon in science happens on its own.					
3. Doing experiments is not as good as getting information from a teacher.					
4. Problem-solving is easy when we already have solutions.					
5. Reading about the experiment is better than doing them to get knowledge.					
6. Science in schools should be given more weightage in terms of time.					
7. Science learning is memorizing facts, concepts, theories and principles in the classroom.					
8. The basis of every phenomenon in the world is the cause-and-effect relationship.					

Appendix

	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
9. It is better to find out things from experts than going for scientific methods to learn science.					
10. It is a loss of time going behind the scientific method when everything is in books.					
11. Science learning is more destructive than constructive.					
12. It is easy to learn science by asking teachers for solutions.					
13. The learning materials covered in science lessons are of no use.					
14. I like to correct my science knowledge whenever there is a chance to unlearn it.					
15. I love days in schools when there is no science lesson.					
16. I like to believe science is fiction.					
17. Time spent on science lessons in secondary schools is a waste of time.					
18. I love and enjoy science lessons.					
19. I like finding solutions to problems through systematic steps and procedures.					
20. I don't work on science lessons after regular instructional hours.					
21. I prefer getting information from teachers than doing experiments.					
22. Science is the most exciting subject.					
23. I like to do new experiments that I read in journals and magazines.					
24. I never miss science lessons.					
25. I like to spend more time engaging with science-related processes.					
26. I can't concentrate too long while engaging with science-related programs.					

II. Indicate your preparedness as a science teacher by marking your correct response in the appropriate column.

		Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
As a Teacher Trainee I	27. Gained and equipped with good content and pedagogic knowledge to be an effective physics teacher.					
	28. Know thoroughly about the syllabus and curriculum at the secondary level.					
	29. Can communicate the concepts in physics clearly to the learner.					
As a Teacher Trainee I	30. Can set reasonable learning goals and learning outcomes in physics lessons.					
	31. Can design suitable learning activities for learners for all topics to attain learning goals.					
	32. I can help my students attain higher-order learning objectives.					
	33. Can integrate ICT in physics lessons to promote learning.					
	34. I am aware of all possible difficulties, and misconceptions students might have at the secondary level.					
	35. Have sufficient skills and strategies for teaching physics lessons at the secondary level.					
	36. I am confident in using assessment and evaluation techniques to provide feedback to students about their learning.					
	37. Can diagnose and eliminate learning difficulties and misconceptions in physics learning.					
	38. Can develop assessment/evaluation tools to promote learning of physics.					

		Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
	39. Can incorporate effective classroom management techniques in challenging classroom situations.					
	40. Can motivate and handle students having difficulty in learning.					
	41. I am good at collaborating with students smoothly in learning physics.					
	42. I am capable of using available resources to improve my professional knowledge.					

III. Indicate the extent of the teacher educator's motivation in shaping a teacher in you.

		Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
Teacher Educator	43. Make sure that adequate instructional facilities are made available to enhance performance					
	44. Give fair consideration to all trainees in the assignment of responsibilities and work.					
	45. Provide opportunities to express views and feelings.					
	46. Assist in solving personal problems.					
	47. Give good commendation for tasks done.					
	48. Engage trainees without any prejudice.					

		Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
	49. Make use of modern technology in the classroom.					
	50. Provide a clear picture of educational practices and major issues in contemporary educational practices.					
	51. Provide healthy feedback and make aware of my position through timely evaluation.					
	52. Plays a serious role in the professional development of trainees during the school internship.					
	53. Follow the current trends and development in educational research.					
	54. Spend sufficient time on individual student trainees.					
	55. Provide support in selecting appropriate learning activities.					
	56. Focuses on proper designing of learning objectives by teacher trainees.					
	57. Incorporate adequate leisure activities and programs in the classroom.					
	58. Uses constructive criticism in correcting faults and errors made by the learners.					

Appendix E

LIST OF COLLEGES

University of Calicut

Sl. No.	Name of the College	No. of Samples
1	Ansar Training College for Women , Perumpilavu, Thrissur	24
2	Bafakhy Yatheemkhana B.Ed Training College Kalpakanchery, Malappuram	13
3	Bhavan's Ramakrishna Institute of Teacher Education, (Unaided),Ramanattukara, Kozhikode	15
4	Calicut University Teacher Education Centre, VK Krishna Menon Road,PO Kallai, Calicu	8
5	CK Raghavan Memorial College of Teacher Education (Unaided), Kalanadikolly, Pulpally, Wayanad	10
6	EMEA Training College, Kondotty, Malappuram	19
7	Farook B.Ed College, Kottakkal	15
8	Farook Training College, Farook College PO	10
9	Govt College of Teacher Education, Kozhikode	4
10	Institute of Advanced Studies in Education, Palace Road Thrissur	6
11	KET College of Teacher Education, Balussery	12
12	KMO College of Teacher Education, Koduvally, Kozhikode	12
13	MCT Training College, Melmuri, Malappuram	10
14	Mother Teresa College of Teacher Education, Perambra	16
15	NSS Training College Ottappalam	12
16	Sree Narayana College of Teacher Education(Unaided), Chelannur, Kozhikode	14
17	TIM Training College(Unaided), Nadapuram, Kozhikode	14

Mahatma Gandhi University

Sl. No.	Name of the College	No. of Samples
18	Adi Sankara Training College, Sankar Nagar, Mattoor, Kalady P.O., Ernakulam Dist.	13
19	Avila College of Education, Edacochin, Ernakulam - 682006	12
20	Hill Valley College of Education, Thrikkakara, Kochi	10
21	Mar Severios College of Teacher Education, Chengaroor, Kunnamthanam, Mallappally, Pathanamthitta - 689 594	9
22	M.E.S. Training College, Edathala, Aluva	15
23	Sahodaran Ayyappan Memorial College of Education, Puthen Kavu, Poothotta, Ernakulam - 682 307	10
24	Sree Narayana Training College, Okkal P.O., Perumbavoor, Ernakulam Dist.	5
25	N.S.S. Training College, Changanacherry, Kottayam Dist.	12
26	S.N.M. Training College, Moothakunam, Ernakulam Dist., (Backward Community College)	10
27	St. Joseph's College of Teacher Education for Women, Ernakulam	10
28	St. Joseph's Training College, Mannanam, Kottayam Dist.	10
29	Titus II Teahers College, Tiruvalla	4
30	St. John the Baptist College of Education, Nedumkunnam, Changanacherry, Kottayam - 686 542	18
31	Auxillium College of Education, Kidangoor P.O., Angamaly	10
32	College of Teacher Education, Elanthoor Vocational Higher Secondary School Campus, Elanthoor, Pathanamthitta, PIN 689 643	10
33	College of Teacher Education, Erattupetta Govt. Higher Secondary School Campus, Thekkekkara, Erattupetta, Kottayam Dist., PIN 686 121	10
34	College of Teacher Education, Kanjirappally Govt. High School Campus, Petta, Kanjirappally, Kottayam Dist., PIN - 686 507	10

Sl. No.	Name of the College	No. of Samples
35	College of Teacher Education, Kudamaloor, Govt. High School Campus, Kudamaloor, Kottayam Dist., PIN 686 017	10
36	College of Teacher Education, Muvattupuzha Govt. Model High School Campus, Muvattupuzha, Ernakulam Dist., PIN 686 661	10
37	College of Teacher Education, Paippad Govt. High School Campus, Paippadi, Changanacherry, Kottayam Dist., PIN 686 537	10
38	College of Teacher Education, Tripunithura, Near Govt. Boys High School Campus, Vaikom Road, Trippunithura, Ernakulam Dist., PIN 682 301	11
39	Nirmala Training College, Thalacode, Mulanthuruthy (Via.), Ernakulam	6

University of Kerala

Sl. No.	Name of the College	No. of Samples
40	Govt. College of Teacher Education, Thycaud, Thiruvananthapuram - 14	4
41	SN Training College, Nedunganda, Varkala	12
42	Mar Theophilus Training College, Bethany Hills, Nalanchira P.O., Thiruvananthapuram - 695015	8
43	Karmela Rani Training College, Fatima Road, Near St. Alosius H.S.S., Kollam - 691013	5
44	Mount Tabor Training College, Pathanapuram - 689695	10
45	NSS Training College, Pandalam	8
46	Peet Memorial Training College, Mavelikkara	6
47	Fathima Memorial Training College, Vadakkevila, Kollam	10
48	CSI College of Education, Parassala	6
49	Baselios Marthoma Mathews II Training College, Kottarakkara	7
50	Mannam Memorial Training College, Vilakudy, Kollam	8

Sl. No.	Name of the College	No. of Samples
51	Sobha College of Teacher Education, S.L. Puram P.O., Mararikulam, Cherthala, Alappuzha	7
52	BNV College of Teacher Education, Thiruvallam, Thiruvananthapuram	10
53	KTCT College of Teacher Education, Koduvayil, Thottacadu, Thiruvananthapuram	10
54	New B.Ed. College, Nellimoodu, Thiruvananthapuram - 695524	6
55	St. Thomas Training College, Mukkolakkal, Thiruvananthapuram	10
56	Buddha College of Teacher Education, Muthukulam North, Alappuzha	5
57	Mannam Foundation Centre for Education Technology, Poruvazhy, Edakkad P.O., Kollam	5

Kannur University

Sl. No.	Name of the College	No. of Samples
58	Govt. Brennen College of Teacher Education	4
59	PKM College of Education	5
60	Crescent B.Ed. College	13
61	SVM College of Teacher Education	8
62	Malabar B.Ed. Training College	12
63	Mahatma College of Education	10
64	Jaybees Training College of B.Ed.	5