PEDAGOGICAL CONTENT KNOWLEDGE ANALYSIS OF PHYSICAL SCIENCE

Dr Sajeena S.
Principal
H.K.M. College of Education
(Affiliated to University of Kerala)

ABSTRACT

Pedagogical Content Knowledge (PCK) is a form of representation of ideas, explanations, and ways of formulating and conveying the contents in order to be understood by the students. The PCK as a combination of content knowledge and pedagogy that is a special form of professional understanding of teachers. PCK is an idea that is rooted in the belief that the learning process requires more than just providing learning content to students, and students learn more than simply absorbing information. Here, the steps of doing a pedagogic content analysis are explained. Ways of doing content analysis, ways of writing learning outcomes, details of prerequisites, the teaching learning processes including the teaching-learning resources and environmental inputs, enrichment activities, techniques that can be employed for assessment purpose, and the ways of giving assignments are included in this paper.

Key Terms: Content analysis, pedagogic knowledge, PCK

INTRODUCTION

Pedagogic analysis is highly complex, deeper, and meant to make a thorough analysis of the curriculum in its totality. Here the curriculum is conceived as the sum total of all learning experiences gained within and outside the class. It is attempted in order to help the teacher to adopt strategies for transacting the curriculum effectively. As a matter of fact, pedagogic analysis and pedagogical analysis are synonymous.

Objectives Pedagogic analysis

The specific objectives of pedagogic analysis are listed below:

1. To analyse the curricular content into meaningful components that constitute the curriculum in its totality.

2. To anticipate comprehensive instructional objectives appropriate to each component of the content and the developmental level of the learners.

3. To identify the pre-requisites essentially needed for assimilating the curricular materials and

experiences

4. To enumerate comprehensively the inputs that might be required for effective curriculum transaction and to adopt strategies for pooling the inputs.

5. To design stage-appropriate, content appropriate and objective based learning experiences by which the inputs could be processed and objectives realised

6. To anticipate probable difficulties and derive strategies for remediation and compensation wherever needed.

7. To anticipate strategies for continuous and comprehensive evaluation leading to mastery learning.

Scope of Pedagogic analysis

The scope of pedagogic analysis can be summarised as below:

1. It forms an integral part of curriculum in all teacher education programmes.

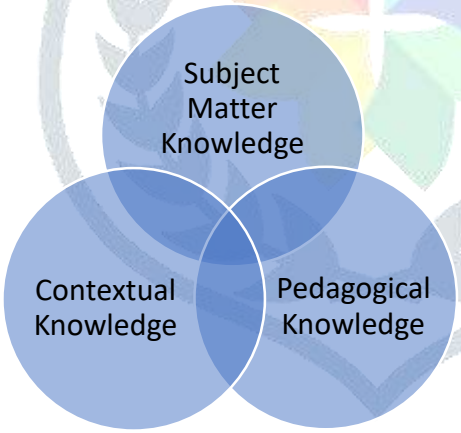
2. It helps the teacher to set educational goals in accordance with the needs and abilities of the learner as well as the characteristics of the content material.

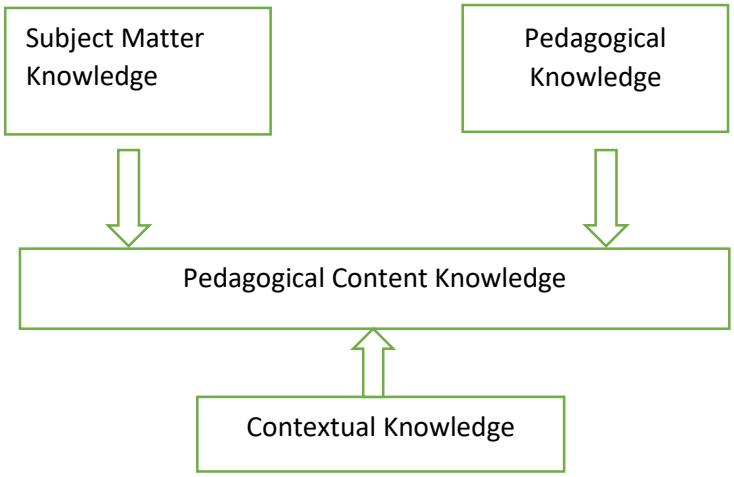
3. It provides the teacher deeper insight into the curricular material and enables him to plan for realising maximum output.

4. It helps the teacher in pooling the resources required for effective instruction.

5. It would help the teacher to anticipate difficulties and to be prepared for handling such situations.

6. It enables the teacher to search for effective tools and techniques for continuous evaluation and to use the results of this evaluation for monitoring the instructional process.





The concept of pedagogical content knowledge (PCK) was introduced by Shulman (1986). The concept of PCK refers to teachers' interpretations and transformations of subject-matter knowledge in the context of facilitating student learning. Shulman introduced PCK as a specific category of knowledge. The key elements in Shulman's conception of PCK are knowledge of representations of subject matter on one hand and the understanding of specific learning difficulties and student conceptions on the other. A qualified teacher not only transfers knowledge of the subject matter he/she owns, but without a good pedagogy content knowledge, it is difficult for future teachers to understand a new knowledge and construct it with the previous knowledge they have acquired. This is because many teachers do not do the planning in terms of teaching a material and do the best effort to make learning so as to make it something easily comprehensible (Agustina 2015). The relationship between content and pedagogy can be explained as follows. Content knowledge expects teachers to connect and see the relationships between material concepts, while pedagogical knowledge expects teachers to master the ways that can help students learn about the concept (Loughran, 2012). The content knowledge prepares future teachers to learn and teach by inquiry process, while pedagogical knowledge allows teachers to transfer experience to students in the process of inquiry.

PCK Analysis- STEPS

1. Content Analysis

Content analysis is an important step in the planning of a lesson. Science teachers need to understand the nature of content as well as skills to be developed while designing the instructions. While planning any teaching-learning strategy, the first thing which have to be focussed is the nature of content and which skill can be developed through it. The instructional materials can be effectively designed after establishing the link between skills required and the nature of content.

Planning of instruction helps the teacher achieve the desired objectives. A scientific and systematic instructional planning enables the teacher to be fully in command of instruction. For this the teacher has to utilise his imagination, creativity, insight and subject competency. Content analysis is main component of instructional planning

The content is the means to the end of bringing about desirable changes in the pupils. A teacher analyses the content to decide what objectives he can develop in his pupils based on the content. A teacher can limit the contents to be taught according to the educational and learning needs of pupils even though the content is vast in nature. This can be done if the teacher analyses the content to be taught to a particular class. Content analysis is the breaking of the content into its constituent parts. In this process the teacher breaks the topics given in the curriculum into their component parts, arranges them in sequence, refines and limits the topic.

The syllabus is only an indication of the prescribed content and as such does not prescribe the order in which topics should be dealt with. Therefore, the teacher has to analyse it properly, and ensure that it is technically accurate and up to date. He later breaks the topic into small constituent sub topics and their

elements, and ensures that the elements are a part of the main topic. Content differs in its depth and elaboration. Certain elements of the analysed content do not match the mental level and age of students. The same content may be taught at various standards but the scope and limit of the content is determined by the level of teaching a particular class of students. Thus, content analysis helps in refining and limiting the content according to the needs and interest of the pupils. After limiting the scope of the content, the next step in content analysis is the arrangement of analysed elements into some type natural sequence.

The basic components of the content of science are:

Terms

Facts

Concepts

Principles

Processes

Theory

Law

Terms: The scientific vocabulary constitutes the terms which are frequently used in scientific literature. A knowledge of the scientific vocabulary at various grades is essential for the learners to read and comprehend science with satisfaction. A **term** is a new definable word having significant meaning to the pupil at a particular context. It is actually a label of a concept. When we teach the topic sound, Induced vibration, Hertz, Decibel etc. are terms. In this context it should never be forgotten that each of these terms is the name given to a concept.

Facts: It is an unadulterated statement of an object, event, phenomenon etc. Facts are specific verifiable pieces of information obtained through observations. They are verifiable with reference to time and place.

Water boils at 100°C.

Iron is a hard metal

Density of mercury is greater than water

These are facts to high school students as the words boils, metal, density etc are familiar to them. But for those students who have not familiarised these words, they are not facts. Hence facts are simple observable truth which can be realized, at a particular stage, without further learning.

Concepts: Concepts are abstract ideas that are generalised from facts or specific relevant experiences. They are the composite of individual facts and emotional experiences. According to Bruner a concept is a mental imagery of a category of objects or phenomena. A concept has five elements viz name, exemplars, attributes, attribute value and definition. eg: Chemical change, acceleration, oscillation etc.

Each of the above represents a generalised mental imagery regarding all members belonging to a category, formed on the basis of a set of essential common characters or attributes.

Principles: Principles are more complex ideas based on several concepts. It is a statement predicting inter relationship among concepts. It establishes relationship between at least two concepts. So, the principles are a broad generalisation which means the same for all irrespective of their age and experiences.

eg- When volume increases pressure decreases; Temperature increases with increase in pressure.

Processes: Processes are really a series of tasks with a sequential order of occurrence. These sequences or steps may be controlled by certain principles.

Eg: Preparation of Hydrogen sulphide, Formation of an electric circuit, Corrosion, Saponification.

Theory and Law: Broadly related principles that provide an explanation for phenomena are known as theories or laws. They are used to explain, predict and relate various facts and phenomena. Theories confirmed by various scientific experimentation by scientists over a period of time become laws.

eg:- Newton's law of motion, Boyel's law, Modern periodic law

For practical purposes of planning instructional strategies, the teacher can consider principles, theories and laws in the same manner.

2. Learning Outcomes

Learning outcomes are an essential part of any unit outline. A learning outcome is a clear statement of what a learner is expected to be able to do, know about and/or value at the completion of a unit of study, and how well they should be expected to achieve those outcomes. It states both the substance of learning and how its attainment is to be demonstrated.

Learning outcomes are statements of what is expected that a student will be able to DO as a result of a learning activity. Learning outcomes help instructors more precisely to tell students what is expected of them. By doing this, educationalists assert that they:

- help students to learn more effectively. They know where they stand and the curriculum is made more open to them.
- make it clear what students can hope to gain from following a particular course or lecture.
- help instructors to design their materials more effectively by acting as a template for them.
- help instructors select the appropriate teaching strategy, for example lecture, seminar, student self-paced, or laboratory class. It obviously makes sense to match the intended outcome to the teaching strategy.
- help instructors more precisely to tell their colleagues what a particular activity is designed to achieve.
- assist in setting examinations based on the materials delivered.

• ensure that appropriate assessment strategies are employed.

Writing learning outcomes

Begin with an Action Verb: Begin with an action verb that denotes the level of learning expected. Terms such as *know*, *understand*, *learn*, *appreciate* are generally **not** specific enough to be measurable. Levels of learning and associated verbs may include the following:

- Remembering and understanding: recall, identify, label, illustrate, summarize.
- Applying and analyzing: use, differentiate, organize, integrate, apply, solve, analyze.
- Evaluating and creating: Monitor, test, judge, produce, revise, compose.

Follow with a Statement

- **Statement** – The statement should describe the knowledge and abilities to be demonstrated. For example:

- Identify and summarize the important feature of the chemical reaction
- Apply important chemical concepts and principles to draw conclusions about chemical reactions

Examples of writing learning outcomes are

Students will……

1. recall the objects which were floating and sinking on water
2. identify the shapes of objects which were floating and sinking
3. understand the laws of floatation
4. apply the laws of floatation in hydrometer
5. develop skill in observation and interpretation in scientific experiments

You can use Bloom's taxonomy to identify verbs to describe participants' learning. Examples of learning outcomes might include:

1. **Knowledge/Remembering**: define, list, recognize;
2. **Comprehension/Understanding**: characterize, describe, explain, identify, locate, recognize, sort;
3. **Application/Applying**: choose, demonstrate, implement, perform;
4. **Analysis/Analyzing**: analyze, categorize, compare, differentiate;
5. **Evaluation/Evaluating**: assess, critique, evaluate, rank, rate;
6. **Synthesis/Creating**: construct, design, formulate, organize, synthesize.

3. Pre-requisites/Previous Knowledge/Entry Behaviour

Of the three terms, the term pre-requisite is more appropriate for it focuses on the required previous knowledge/entry behaviour without which the teacher cannot proceed. It is crucial in the development of a lesson to isolate the pre-requisite from where the class should begin. The pre-requisite is not necessarily something that the student has learned in the previous class(es). It can be an experience or an anecdote. The purpose of identifying the pre-requisite is to start the lesson from where the students are. It also helps in arousing the apperception mass thereby motivating the students to learn.

Pre-requisites are needed for assimilating the new learning materials of the content or the unit should be comprehensively listed. These may include all familiar schemes that might be required for assimilating new and unfamiliar schemas to be presented while transmitting the curriculum. For example, familiar facts and pre-concepts may be essentially required to assimilate and internalize new broad concept. In the same way in order to comprehend a new principle the learner should possess the concepts involved as well as the preliminary principles based upon which the new principle is being developed. In the same way the relevant principles and skills will be the prerequisites for learning a process.

4. Teaching-learning processes

Teaching is the process of attending to people's needs, experiences and feelings, and intervening so that they learn particular things, and go beyond the given. Teaching is one of the instruments of education and is a special function is to impart understanding and skill.

The main function of teaching is to make learning effective and meaningful. The learning process would get completed as a result of teaching. So, teaching and learning are closely related to each other. Teaching is a process in which one individual teaches or instruct another individual.

Teaching is considered as the act of imparting instructions to the learners inside and outside the classroom situation. Teaching and learning process is the part and parcel of the education system. Whole education system depends on the aims and objectives of the teaching & learning process.

In the teaching-learning process, the teacher, the learner, the curriculum are organised in a systematic way to achieve the educational goals and objectives. Learning is an inferred process and differs from the performance which is the observed behaviour/response/action.

a) Teaching and learning resources

The 'teaching and learning resources' referred to in the guidelines include any spoken, written or visual text or activity used or conducted by schools. Learning Resources refer to any person(s) or any material (whether acquired or locally produced) with instructional content or function that is used for formal or informal teaching-learning purposes. Learning resources may include, but are not limited to, print and non-

print materials; audio, visual, electronic, and digital hardware/software resources; and human resources. In a broader perspective learning resources includes human resource as well as physical resources.

Some of the frequently used classroom resources may be enlisted as follows:

• Teacher's thoughts

• Children's thoughts

• Thoughts of community members

• Blackboard and other writing boards

• Books/textbook/worksheets

• Audio resources like radio, tape recorder, mobile phone, etc.

• Visual resources like charts, pictures, models, epidiascope, micro-projector, film strips, etc.

• Audio visual resources like television, motion pictures, video films, living objects, etc.

• Interactive ICT resources like internet, computer, mobile and tablet, etc.

• Improvised and localized resources.

b) Environmental inputs

Inputs means the instructional aids that can be used for effective instruction. There should be a wide range, from routine or innovative instructional aids to a visit to significant spots, business centres etc. Any mediator, such as examples, anecdotes, analogies, stories etc or any aid gathered from physical, natural and social environments should form part of the list. The listed inputs may be processed for providing the content-appropriate, objective based, learner centred, environmental based, process oriented and comprehensive learning experiences.

5. Enrichment activities

This gives students a chance to do something independently which will give teachers a chance to do formative evaluation or to enable them to carry the activity further and apply learning in a personal way. This step makes learning more permanent. It could be an in-class activity which is completed later, a learning centre, seat work, or home work.

6. Assessment techniques

Learning goals can be assessed in a variety of ways, including through quizzes, tests, independently performed worksheets, cooperative learning activities, hands-on experiments, oral discussion, question-

and-answer sessions, writing assignments, presentations, or other concrete means. Most importantly, teachers need to ensure that the Assessment activity is directly and explicitly tied to the stated learning objectives you developed in step one of the lesson plan.

Follow-Up: Using the Results of the Assessment

Once the students have completed the given assessment activity, teacher must take some time to reflect on the results. If the learning objectives were not adequately achieved, teacher will need to revisit the lesson in a different manner, revising the approach to learning. Either need to teach the lesson again or need to clear up areas that confused several of the students.

Student performance on one lesson tends to inform performance on future lessons, giving the teacher an insight into where the teacher should take students next. If the assessment showed the students fully grasped the topic, then can proceed immediately to more advanced lessons. If understanding was moderate, want to take it slower and reinforce the takeaways. This may require teaching the entire lesson again, or, just portions of the lesson. Assessing different aspects of the lesson in greater detail can guide this decision.

Examples of Types of Assessments

- Quiz: a short series of questions with right and wrong answers that may not count towards a grade.
- Test: a longer or more in-depth series of questions that probes for more understanding of the topic and may count towards a grade.
- Class discussion: rather than a quiz or test that is scored, a discussion helps identify understanding. It's important to make sure all students are able to demonstrate mastery here, so that no one is lost in the shuffle.
- Hands-on experiment: Where the subject matter is appropriate, the students apply the lesson to an experiment and record the outcomes.
- Worksheet: Students fill out a worksheet, especially for math or vocabulary lessons, but it also could be developed for many topics.
- Cooperative Learning activities: Students work in a group to solve a problem or have a structured discussion.
- Illustrations or Graphic Organizers: These can include Venn diagrams, K-W-L (Know, Want to Know, Learned) charts, flow charts, pie charts, concept maps, character traits, cause/effect diagrams, spider web etc.

7. Assignments

Assignments can be provided as part of the instruction should be decided in advance. An assignment based on the continuation of the in the classroom is very helpful for the students understanding. As far as possible, assignment should emerge out of the group planning in the class, it should not be dictated by the teachers. There should be the scope for critical thinking, creativity and open-ended responses in the assignment.

Assignments should be planned for extended learning, self-learning and in a forwardlooking manner rather than only in a backward looking manner i.e. doing routine type exercises at the end of the lesson. Learners can also be given assignment at the planning stage of the lesson. If a principle has been transacted in the class and students are given the assignment to make a model based on the principle or extended learning, they will not only understand the principle better, their understanding on construction and working and the model making skills will also get enhanced.

CONCLUSION

PCK is knowing what, when, why, and how to teach using a reservoir of knowledge of good teaching practice and experience. The development of Pedagogical Content Knowledge is critical for the science educator. Pedagogical content knowledge requires an understanding of where students are coming from in reference to the subject being taught. Teachers with good pedagogical content knowledge must have a good grasp of which aspects of their subjects are typically easy for students and which they are typically more difficult.

REFERENCES

Burton, E. P. (2013). Student work products as a teaching tool for nature of science pedagogical knowledge: a professional development project with in-service secondary science teachers. *Teaching and Teacher Education*, 29 (1), pp. 156–166.

Davis, E., Annemarie Sullivan Palincsar, A. S., Arias, A. M., Bismack, A. S., Marulis, L., & Iwashyna, S. (2014). Designing educative curriculum materials: A theoretically and empirically driven process. *Harvard Educational Review*, 84 (1), 24 –52 https://doi.org/10.17763/haer.84.1.g48488u230616264

Hashweh, M. (2005). Teacher pedagogical constructions: A reconfiguration of pedagogical content knowledge. *Teachers and Teaching: Theory and Practice*, 11, 273 –292.

Kinach, B. M. (2002). A cognitive strategy for developing pedagogical content knowledge in the secondary mathematics methods course: toward a model of effective practice. *Teaching and Teacher Education*, 18 (1), pp. 51–71.

Kind, V. (2009). Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education*, 45 (2), 169–204.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. AACTE committee on innovation and technology (Ed.). *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29).

Loughran, J., Berry, A., & Mulhall, P. (2012). *Understanding and Developing Science Teachers' Pedagogical Content Knowledge*. Sense Publishers.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

Palanisamy, P., Paavizhi, K., & Saravankumar, A. R. (2019). Techno pedagogical skills for teaching-learning process in smart class. *Talent Development & Excellence*, 12 (1), 4984-4994

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1–22.

Van Driel, J. H., & Berry, A. (2012). The teacher education knowledge base: Pedagogical content knowledge. *Third International Encyclopedia of Education*, 7, 656 –661

Van Driel, J., & Verloop, N. (1998). Pedagogical content knowledge: a unifying element in the knowledge base of teachers. *Pedagogische Studiën*, 75, pp. 225–237.

Sperandeo-Mineo, P. M., Fazio, C., & Tarantino, G. (2006). Pedagogical content knowledge development and pre-service physics teacher education: a case study. *Research in Science Education*, 36 (3), pp. 235–268, 2006.