DESIGNING LESSON PLAN IN SCIENCE BASED ON TPACK FRAMEWORK

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Technological Pedagogical Content Knowledge (TPACK) has been introduced as a conceptual framework based on the notion that teachers need to align and integrate content, pedagogy, and technology in their teaching practice in order to make the classroom process interactive and learning meaningful and effective. This paper presents a brief description of how to design and develop a lesson plan based on the TPACK framework in teaching science with illustrations in a systematic manner.

Keywords: TPACK, Lesson Plan, Education, Teaching Strategies.

Introduction

In traditional teaching, content and teacher played an important role, where textbooks were the only source of content. However, education in the digital era is more student-centred. Now education favours a curriculum that focuses on the enhancement of the competency of students. Although not previously considered among the traditional frameworks for research in education, in recent times, however, PCK offers a new perspective for science education research within teacher education. The notion of pedagogical content knowledge was first introduced by Shulman as a form of knowledge that connects a teacher's cognitive understanding of subject matter content, and the relationships between such understandings with the instruction teachers provide for students (Shulman, 1986:25).

Research has shown that in order to improve the quality of science education, science teachers need to possess knowledge of learners, content, pedagogy, and technology. Recently, considerable interest has surfaced in using the notion of Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006; as a framework for the teacher knowledge required for effective technology integration because TPACK reconnects technology to curriculum content and specific pedagogical approaches. This paper discusses TPACK framework and designing a lesson plan in science based on it with an illustration.

What is TPACK?

Technological Pedagogical Content Knowledge is a framework that tries to identify the nature of knowledge required by teachers to teach effectively with technology. The TPACK framework describes how teachers' understandings of technology, pedagogy, and content can interact with one another to produce effective discipline-based

teaching with educational technologies. In this framework, there are three interdependent components of teachers' knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK); when these (CK, PK, and TK) interact with each other, they form PCK, TPK, TCK, and TPACK (Fig. 1). That is, there are seven components in total. Effective integration of CK, PK, and TK by the teacher would help in meaningful classroom transactions.

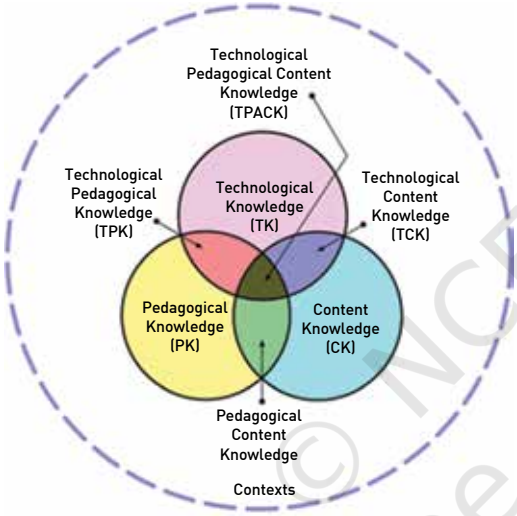

Fig. 1. TPACK with its Components

Content Knowledge (What to teach)

Teachers' knowledge of the content or subject matter (components of scientific knowledge) that has to be transacted in the classroom is called content knowledge. It includes factual knowledge and procedural knowledge. The teacher needs to analyse the content to be taught in order to understand the nature of the content.

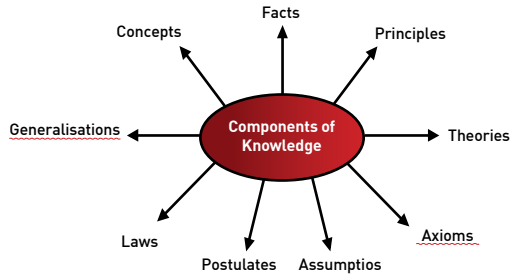

Fig. 2. Components of Knowledge

Content Analysis

The subject matter or content has to be analysed in order to understand the nature of the content and identify content categories or components of scientific knowledge from the chosen content. After analysing the content, the teacher understands the nature and scope of the content—whether it is descriptive, exploratory, illustrative, procedural, etc. Content knowledge includes knowledge of facts, concepts, principles, laws, theories, generalisations, etc. (Fig. 2).

Example: Content analysis of the topic Cell and its Types

The content of the lesson is exploratory in nature, wherein students can be given an opportunity to explore different types of cells. The teacher can facilitate and orient the students in handling the microscope. The content is illustrative as there is the scope of giving examples of different shapes of cells, unicellular and multicellular organisms. The content contains facts, principles, theories, concepts, and generalisations. The content may be categorised as shown in Table 1.

Table 1
Content categorisation of the topic Cell

Facts	Concepts	Theory	Generalisation
The Cell was first discovered by Robert Hooke in 1665. The nucleus was discovered by Robert Brown. Schleiden and Schwann proposed cell theory The Cell is the structural and functional unit of life	Cell Organelle Microscope Multicellular organisms Unicellular organisms	All plants and animals are composed of cells, and the Cell is the basic unit of life. All cells come from the pre-existing cells	All living organisms are made up of cells Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. Different kinds of cells perform different functions.

Pedagogical Knowledge (How to teach)

Teachers' knowledge of the learning process, the context of learning, methods/approaches/ strategies/processes involved in the teaching-learning process is called pedagogical knowledge. It also includes an understanding of how students learn, planning a lesson, classroom management, and continuous comprehensive assessment of students. Once the content is analysed, it is vital to decide how to teach students. Some of the teaching strategies are given in Fig. 3.

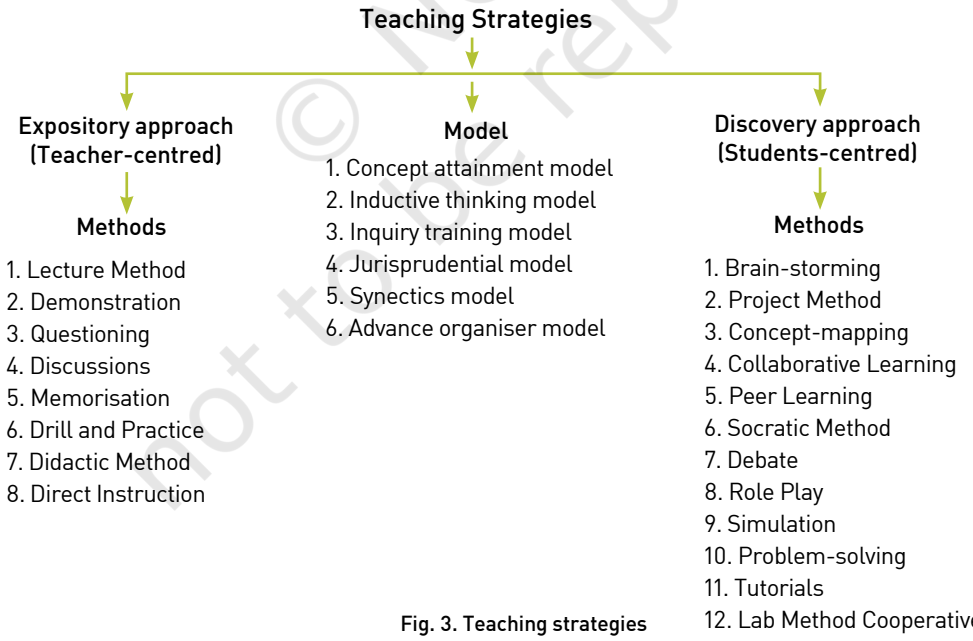

Fig. 3. Teaching strategies

Pedagogical analysis

Depending upon the age, maturity, and intelligence of the students, a stage has to be set in nurturing congenial learning environment by the teachers. The teacher has to make decisions regarding whether individual or group-based learning has to take place, the method/strategy/approach/technique to be adopted, and assessment techniques to be used before the commencement of classroom instruction.

Example: Pedagogical analysis of the topic 'Cell & Cell theory'

To teach 'Cell & Cell' theory, the following pedagogical processes can be taken up:

- Concept attainment model to help the student attain the concept of Cell
- Inductive method to arrive at the statements of Cell theory
- Lab method to show the main parts of the Cell
- Group work and Album making
- Development of Rubric to assess the process of learning

Technological Knowledge

Teachers' knowledge of tools, resources, teaching-learning materials, and their use contextually in the classroom is called technological knowledge. Understanding when, which and how, technology promotes the learning process among the students and would improve the teaching-learning process. Out of many technologies available, the teacher has to determine the ones for the lesson, keeping into consideration affordances and constraints. In addition, the teacher must understand the purpose of using or integrating technology while teaching, which includes:

(a) **Substitution:** Instead of a chart, slides or documents may be shown. In other words, the technology here is not added on but is used as another medium of presentation.

(b) **Modification:** Instead of using papers/letters, the ideas can be shared on google docs wherein there is a mutual exchange in different times and spaces.

(c) **Augmentation:** In this case, the technology can enhance the concept, and augments learning among the students.

(d) **Redefining:** This is the highest level of integration wherein technology is used for transforming learning.

The exemplar resources/materials/tools that can be used in the teaching-learning process are given in Figs. 4 and 5.

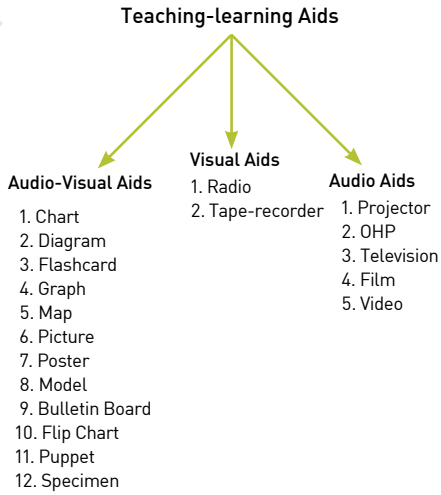

Fig. 4. Teaching-learning Aids

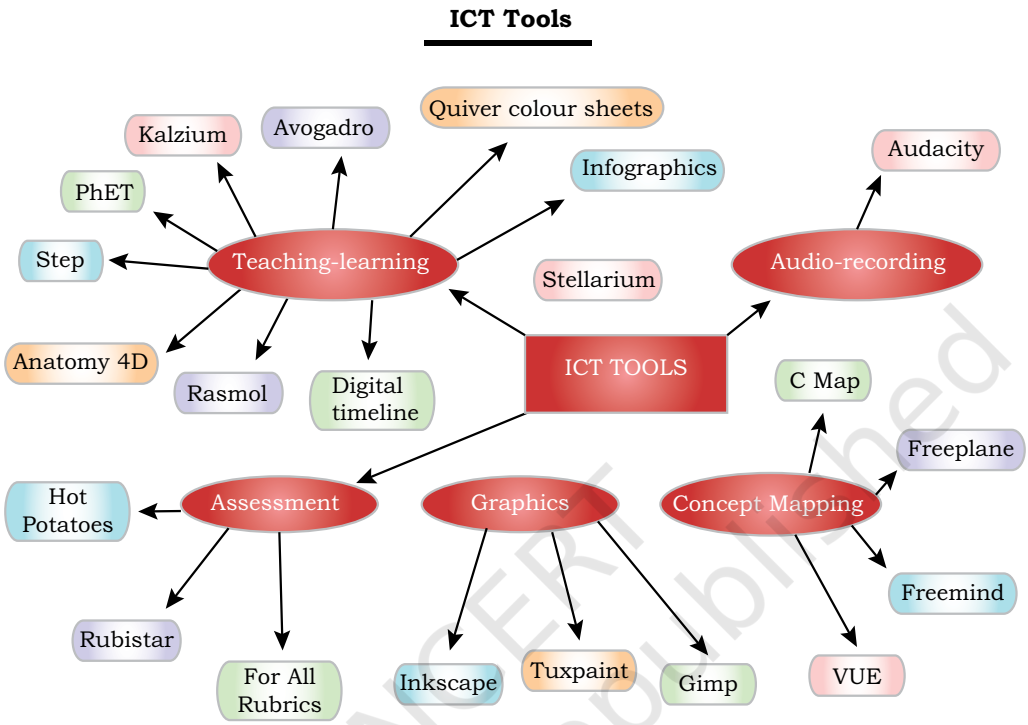

Fig. 5. ICT tools that can be used for teaching

Pedagogical Content Knowledge (PCK)

According to Shulman (1986), PCK is the notion of transforming the subject matter for teaching. This occurs as the teacher interprets the subject matter, finds multiple ways to represent it, adapts, and tailors the instructional materials to alternative conceptions and students' prior knowledge. In addition, PCK includes conditions that promote learning and links curriculum, assessment, and pedagogy (Koehler and Mishra, 2009). In other words, PCK is the specialised knowledge of a teacher that helps him/her decide how to teach the given topic to a group of students, and which materials to use to facilitate learning among the students. This knowledge is enhanced with the teaching experience of teachers.

Example: Cell & its types

An Illustration of PCK is represented in Table 2.

Table 2
Forms of Knowledge and Pedagogical Interventions

Forms of knowledge				Pedagogical Intervention
Factual	Conceptual	Procedural	Meta Cognitive	
Recalls that cell is the structural and functional unit of life			Associates honeycomb compartments with the cells	Allows the students to explore the cells under the microscope (draw the diagram in their notebooks)
	Describes cell theory Generalises that each cell has the capacity to perform certain basic functions that are characteristics of all living forms Differentiates unicellular and multicellular organisms			Uses charts models and encourages the students to discuss the shape, size, and functions of the cells Using the inductive thinking model, the students may be encouraged to arrive at the concepts and differentiate them
		Encourages the students to observe the cell under a microscope using core and fine adjustments		Encourages the students to observe and identify the organisms under the microscope
	Analyses the relationship between the shape and size of the cell with that of function			Encourages students to observe the organisms under the microscope and discuss with one another
	Develops a rubric along with the students and assess the album			Motivates students to participate actively in their group work
	Prepares an album on the life history of scientists Robert Hooke and Schleiden and Schwann			

Technological Content Knowledge (TCK)

Teachers' knowledge of the application of technologies and their suitability for teaching the content chosen or subject matter constitutes Technological Content Knowledge. In other words, TCK is the teachers' understanding of how the subject matter or knowledge is constructed and which technologies are best suited for addressing the same, and even understanding how the content dictates the use of technology.

Example: Cell & its types

- **Cells:** Observation of slides under a Microscope
- **Shapes and sizes of the cells:** Using charts, models, slides
- **Structure of a Cell:** Quiver colour sheets
- **Rubric:** Rubistar
- **Concept map on Cell:** VUE/Free mind
- **Life history of the scientist:** Digital timeline, Digital storytelling
- **Unicellular and multicellular organisms:** PowerPoint presentation, movie maker

Technological Pedagogical Knowledge (TPK)

TP describes teachers' understanding of technologies and their use in the teaching-learning process, pedagogical affordances, and the challenges/constraints. With this knowledge, the teacher can choose the tools that match the students' age, maturity, and other student-related aspects, along with pedagogical interventions that are developmentally appropriate.

Example: Cell & its types.

- **Cells:** Observation of slides under Microscope – Lab method
- **Shapes and sizes of the cells:** Using charts, models, slides – Inductive method
- **Structure of a Cell:** Quiver colour sheets – Group work
- **Rubric:** Rubistar – Group work
- **Concept map on Cell:** VUE/Free mind – The teacher can develop the map with the help of students or use a concept map while developing a lesson
- **Life history of the scientist:** Digital timeline, Digital storytelling - Presentation
- **Unicellular and multicellular organisms:** PowerPoint presentation, movie maker – Inductive thinking model / Concept attainment model of teaching

Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is best explained in the following lines of Koehler and Mishra (2009):"Underlying truly meaningful and deeply skilled teaching with technology, TPACK is different from knowledge of all three concepts individually. Instead, TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn, and how technology can help redress some of the problems that students face; knowledge of students' prior

knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones".

Example: Cell & its types.

in an appropriate context for the students. Technology is integrated with content and pedagogy as it can be used for substitution, modification, augmentation, and redefining. In other words, the whole purpose of integration

Table 3
TPACK format for the topic Cell and its types

Content	Pedagogical interventions	Technological interventions	Assessment
The cell is the structural and functional unit of life Associates the honeycomb compartments with the cells	Allows the students to explore the cells under the Microscope (draw the diagram in their notebooks)	Uses Microscope Colour and scan Quiver colour sheets	Quiz (Hot potatoes)
Describes cell theory Generalises that each Cell has the capacity to perform certain basic functions that are characteristics of all living forms, Differentiates unicellular and multicellular organisms	Uses charts and models and encourages the students to discuss the shape, size, and functions of the cells Motivates the students to develop concept maps Uses the Inductive Thinking Model to arrive at the concepts	Charts, models, PPTs Freemind / VUE PPTs	Concept map for assessment
Life history of scientists	Group work Prepares an album on the life history of scientists Robert Hooke and Schleiden and Schwann Create Rubric for assessing the album	Digital storytelling/ timeline Rubistar	Presentation by students

To develop a lesson based on TPACK, one has to determine the context, content and pedagogy; reflect on PCK; determine technology; reflect on TCK and TPK; develop classroom processes based on TPACK in a sequential manner. An illustration is presented in Table 3.

To sum up, it is necessary that the teacher needs to be resourceful in terms of content and pedagogy, and integrate technology is to enhance the quality of learning by making it enjoyable, meaningful, and outcome-based learning.

An Exemplar Lesson

Class: IX

Subject: Science

Topic: Cell and Cell theory

Content: Cell, Cell theory, Microscope, Unicellular and Multicellular organisms, Life history of scientists

Technology integration: Charts, Models, Videos, PPTs, Microscope, Rubistar, Quiver colour sheets, Hot potatoes, digital storytelling or timeline, Freemind or VUE

Class demographics: Total no. 35, Boys: 20, Girls: 15; Students are from rural and urban areas; No CWSN

Learning goals: At the end of the instruction, the students:

- identify cells.
- generalise that Cell is the structural and functional unit of life.
- explain cell theory.
- differentiate unicellular and multicellular organisms.
- create an album on the contribution of the scientist.
- design a rubric to assess the album.

Pedagogical interventions/activities

Filling quiver colour sheets, observing cells under Microscope, concept attainment model, group work for designing rubrics and developing an album, using charts and models are the pedagogical interventions or activities that can be carried out for teaching the selected content.

Procedure

After setting an ambiance for learning, the teacher may tap students' previous knowledge of characteristics of living things and create readiness among them. For example, an activity may be conducted wherein students explore the structure of Cells by observing onion peel and cheek cells or any other under a microscope and draw a microscopic view of cells (Figs. 6 and 7). If that is not possible, the teacher can use quiver color sheets. The students may be encouraged to fill the quiver colour sheets of plant and animal cells, and scan and observe the cells. Further, they may be asked to describe the cells observed in their own words.

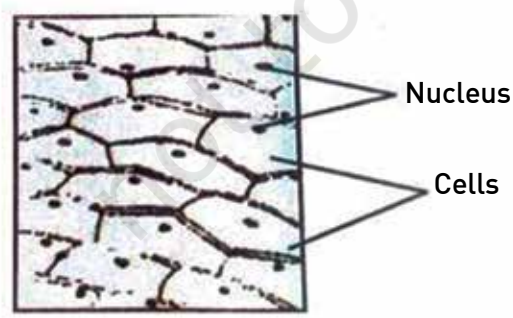

Fig. 6. Cells of Onion peel

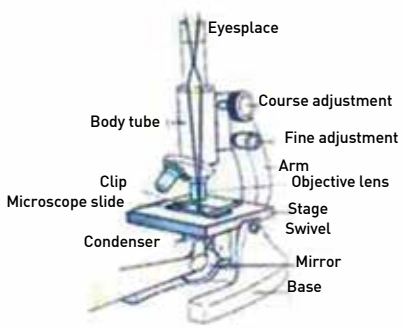

Fig. 7. Parts of a Compound Microscope

The teacher can further use videos to explain the concept of cell theory given by Schleiden and Schwann. Finally, a discussion can take place showing charts and models regarding the different shapes, sizes, and functions of the cell. Based on this discussion, the teacher can encourage the students to generalise that each cell has the capacity to perform certain essential functions that are characteristics of all living forms.

The teacher may use open software like Freemind / VUE to show concept maps to students, for which a laptop or a PC with a projector will be required as shown in Fig. 8.

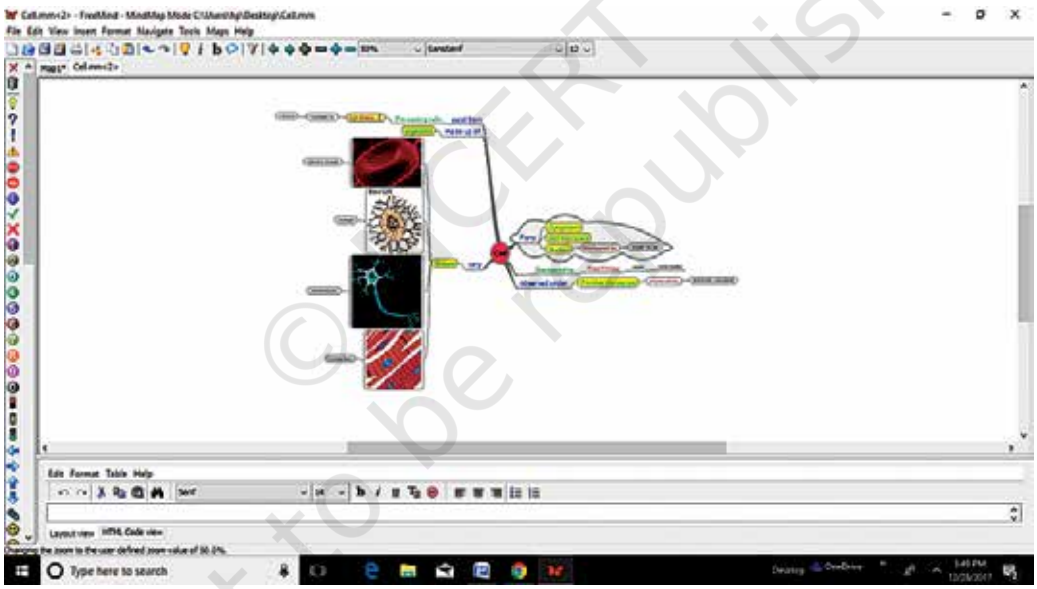

Fig. 8. Freemind software can be used to construct concept maps

Using hot potatoes, the quiz can be conducted in the class to recall the largest, longest, smallest cells, etc.

Teachers may use the Reception or Selection strategy of the Concept Attainment Model of teaching so that students can attain the concept of unicellular organisms and multicellular organisms using PowerPoint presentations or pictures, or images. These teaching models help the students inform and attain concepts through a variety of examples.

Group work can be carried out in which students need to prepare an album on the life history of scientists Robert Hooke and Schleiden and Schwann. For this work, students may take the help of digital storytelling/timeline. The album prepared in the group will be assessed with the rubrics developed in Rubistar.

Conclusion

This framework considers the different types of knowledge needed; it becomes a great possibility of integrating technology into the teaching-learning process. It

further impacts both teachers' professional development and students' learning. Because it considers the different types of knowledge needed and how teachers could cultivate this knowledge. The TPACK framework thus becomes a productive way to consider how teachers could integrate educational technology into the classroom. In other words, it is imperative that the teacher understands the aspects mentioned above and that the class is driven in an integrated way. Technology has become an increasingly important part of the teaching-learning process, especially in understanding complex concepts and helping in collaboration with peers.

References

Mishra, P., and M.J. Koehler. 2006. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record.* Vol. 108, No. 6. pp. 1017–1054. doi: 10.1111/j.1467-9620.2006.00684.x.

Koehler, M.J., and P. Mishra. 2009. What is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education*. Vol. 9, No. 1. pp. 60–70.