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Physics Teachers' Self-reflection about TPACK Competency and Formulation of Technology based Learning Objectives

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Abstract: Physics subject needs empirical evidence to accept any knowledge in its boundary. In modern education system technology help to connect the learner with the outside world for making inquiry-based observations. TPACK framework is an innovative idea that should be adopted by physics teachers to be more efficient in using information and communication technology in the classroom or outside the classroom. In technology-based teaching-learning process competency of teachers for adapting themselves according to the TPACK framework and clarity in learning objectives using digital technology should be much highlighted. In this paper, the researcher has presented the self-reflection procedure in the case of physics teachers for teaching according to the TPACK framework and formulation of learning objectives based on digital Bloom's taxonomy. Statements of learning objectives for secondary class science topic "introduction to the electric circuit" for factual, conceptual, procedural and metacognitive knowledge dimensions have also presented.

Index Terms **- Physics, TPACK, Digital Bloom's Taxonomy, Self-reflection, Learning objectives**

I. INTRODUCTION

Our surroundings are full of scientific mysterious that observed by science. For an example of the cloud passes through the sky, the beauty of sunrise and sunset, the echo formation between mountains, the motion of skydiver, crystalline form of snowflakes and such type of limitless phenomena can be included within the boundary of physics. Physics always tends to conquer the inanimate world with a unifying principle. As human curiosity pervades nature and exhibits the inherited order and simplicity whole civilization so value. It is the inherited order of nature that exposes science as general, and physics as a specific subject. In the modern education system, observation and inquiry of various natural phenomena especially related to inanimate objects get possible due to technology.

Technology has influenced all the teaching-learning processes in physics and its inclusion indicates a progressive attitude towards the 21st century[1]. The education system in the United States is also progressing towards STEM-integrating instruction in science, technology education, engineering, and mathematics. In students' learning blending of science, technology education, and mathematics have shown powerful relationships when it comes to students learning" [2].

There is a wider scope of the use of valuable resources offered by information technology in physics classrooms. New trends in information technology tools can be listed as software/video resources, Internet, simulations, hypermedia, and probeware[3]. Smartphones and mobile tablet devices facilitate learners with continuous and omnipresence access to the internet with the focus on searching knowledge efficiently and making the connection with knowledge sources like web resources, teachers or other learning community[4].

Various studies on the use of technology in education are mostly based on teaching-learning at the cognitive domain as may be observed by the TPACK [5-6] and the ICT-TPCK [7] exemplar frameworks. Seven elements of TPACK (pronounced -tee-pack) are technological knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK) as shown in figure (1). Whereas technology-enhanced learning environment in ICT-TPCK model [7], comprises of pedagogy, content, ICT, learner, and context.

In this digital era learning objectives are as much significant as in the traditional education system when Dr. Benjamin Bloom had presented a taxonomy at the start of 1956 which known as Bloom's Taxonomy[8].In this taxonomy Knowledge, comprehension, Application, Analyze, Synthesis and evaluation are six steps of hierarchy that learners have to follow during learning. Later on a revised form of this taxonomy introduced in 2001 which known as revised Bloom's taxonomy. Revised bloom's taxonomy also has six steps of learning as Remembering, Understanding, Applying, Analyzing, Evaluating and creating. Bloom's taxonomy of the learning objectives devised according to the hierarchical learning scheme of educational psychology and it has wider scope inapplicability[9]. In general, learning for factual knowledge is a difficult task unless learners have a strong prior understanding in that field [10] i.e. learning for recalling of information.

Edger dale's cone of experience (see Fig. 1) is a model that presents practical aspects of instructional designs and learning processes. Dale theorized that learners uphold more information by what they "do" as contrary to what they read or heard. In the modern education system, this theory is more significant and it is popular as "action learning" or "experiential learning"[11].

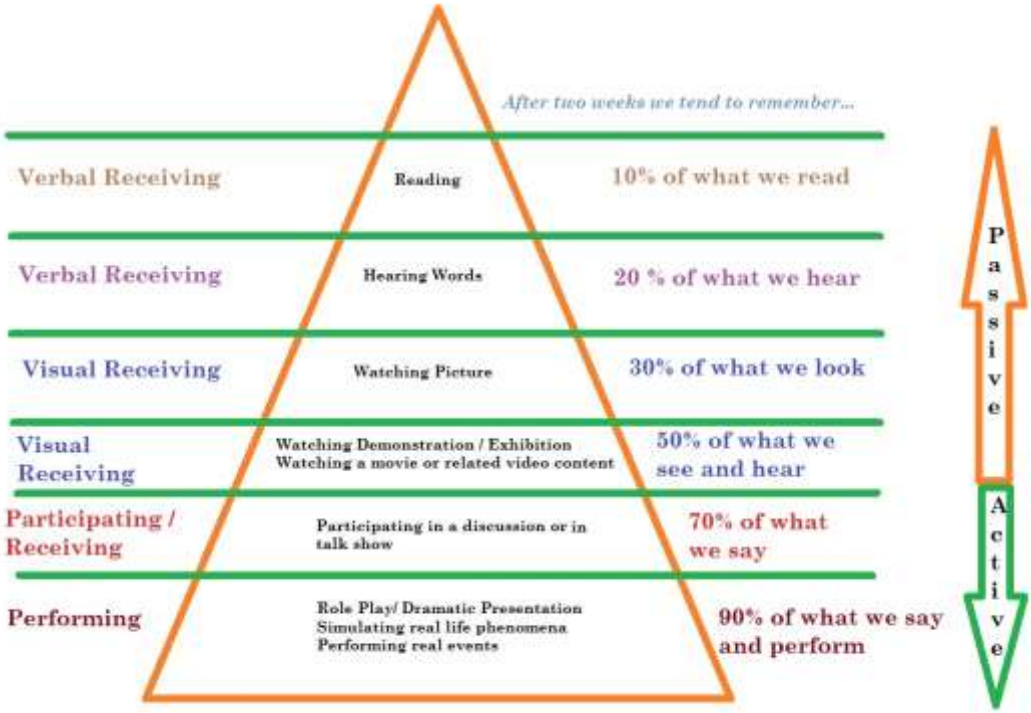

Figure 1:Edgar Dale's Cone of learning

Perceptual learning styles based on sensory experiences. If more sensory channels connected with learning resources then it positively influences learners learning ability[12].

As the STEM curriculum, Edger Dale's theory of sensory experience advocated the teaching-learning environment and the TPACK framework become popular in the 21st-century technology-based education system. The introduction of digital taxonomy for Learning objectives must be taken into consideration during different phases of the digital technology-based teaching-learning process. In this paper, the researcher proposes a plan layout based on a discussion on the following questions :

(a)How a teacher can self-reflect on seven elements of the TPACK framework before administrating technology-mediated teaching-learning sessions?

(b) How a teacher can prepare learning objectives based on digital Bloom's taxonomy in physics subject?

II. DISCUSSION

TPACK Framework

TPACK is a framework consists of its seven elements that introduce the interrelationships between all three basic components of knowledge -technology, pedagogy, and content [13-14].

Seven components (see Fig. 2) involved in the TPACK framework. Physics teachers can become effective in technology-based teaching-learning session when they positively affirmed after a self-reflective inquiry about competency in each of these seven elements of TPACK.

Technology knowledge (TK) Technology knowledge comprises of knowledge about various low-tech technologies such as pencil and paper to digital technologies such as interactive whiteboards, the Internet, digital audio-video system and software programs. Physics teachers can reflect upon a statement for self-inquiry about their competency in TK which is as;

"I know about a lot of different technologies for physics teaching".

Content knowledge (CK) Content knowledge is the knowledge of the subject matter that has to be learned or taught". Content knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026). Teachers must be experts in their subject matter. Physics teachers can reflect upon a statement for self-inquiry about their competency in CK which is as; "I have sufficient knowledge of physics contents ".

Pedagogical knowledge (PK) Pedagogical knowledge refers to knowledge about the art and science of teaching. It helps in proper classroom management, teaching, lesson plan development, and student learning. Physics teachers can reflect upon a statement for self-inquiry about their competency in PK which is as; "I can adapt my teaching style according to need of different learners".

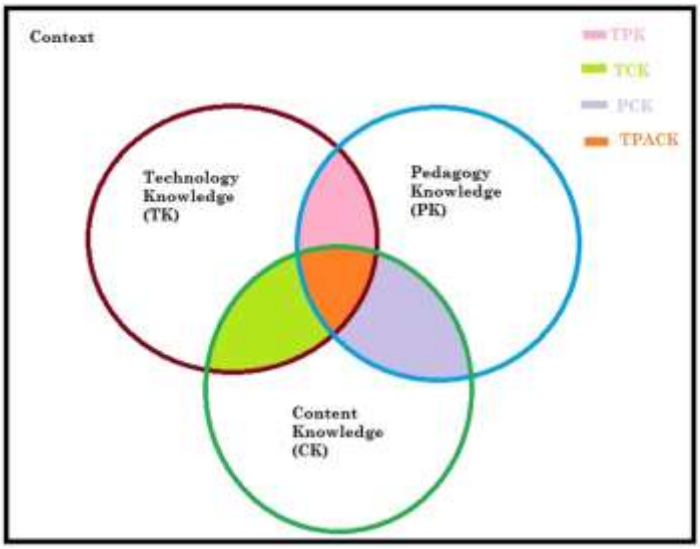

Figure 2: The elements of the TPACK framework, as depicted by Mishra and Koehler (2006) [5]

Pedagogical content knowledge(PCK) Pedagogical content knowledge refers to the knowledge of the subject matter that deals with the teaching approaches. PCK results due to the intersection of PK and CK to develop better teaching practices in the content areas. Physics teachers can reflect upon a statement for self-inquiry about their competency in PCK which is as; "I know how to select effective teaching methods/approaches to make students' performance better in physics content".

Technological content knowledge (TCK) It refers to the knowledge of how technology can create new representations for specific content. Physics teachers can reflect upon a statement for self-inquiry about their competency in TCK which is as; "I know about technologies that I can use to provide an opportunity to learners' for better understanding of physics concepts".

Technological pedagogical knowledge (TPK) Technological pedagogical knowledge refers to the use of various technologies to make teaching-learning interesting and effective. Physics teachers can reflect upon a statement for self-inquiry about their competency in TPK which is as; "I can choose technologies that enhance the teaching approaches to make students able to develop an interest in physics subject".

Technological pedagogical content knowledge (TPACK) Technological pedagogical content knowledge refers to the intersection of the other six elements of the TPACK framework which establishes a complex relationship between technology, pedagogy, and content. Physics teachers can reflect upon a statement for self-inquiry about their competency in TPACK which is as; "I can teach lessons that appropriately combine physics, technologies, and teaching approaches".

Use of Digital Bloom's Taxonomy in Physics Education

Andrew Churches first introduced the idea of "Bloom's Digital Taxonomy" in 2001 and noted that this taxonomy is "not restricted to the cognitive domain rather it contains cognitive elements as well as methods and tooling" [15]. In the development of Bloom's Digital Taxonomy, Churches (2008) added several digital products as additions to each key term in Blooms' Revised Taxonomy. Churches (2009), fused the Revised Taxonomy to the digital age by adding in ways to use Web 2.0 technologies to each cognitive level as shown in Table 1 to 6. Although the hierarchical order of objectives is retained from Bloom's Revised Taxonomy, the digital taxonomy proposed that lower-order digital skills such as searching can be used and learning within the context of critical thinking activities[16] Physics teachers can make .a reflection on their self-inquiry about competency in the TPACK framework and to use technology effectively they can formulate Learning objectives for their lesson planning. Which is presented below in Table 1 to 6:

1. Remembering: This element of taxonomy refers to retrieving, recalling or recognizing Specific term, specific meaning, knowledge of universals and abstractions in a field from memory.

Table 1: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Remembering level of digital Bloom's taxonomy

Action Verbs	**Digital Activities**	**Knowledge type and checklist for self-reflection about expertise in related knowledge type**	**Learning objective** **Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective**
Traditional Action Verb: Recognizing, Listing, Describing, Identifying, Retrieving, Naming,	**Listing** Web publishing Personal web page Blog journal Concept map **Quiz/Test** Online tools Cue sheets **Reproduction** Web publishing Personal web page Blog journal	**TK** I know about a lot of different technologies for communication. **CK** I have sufficient knowledge of electric current and electric circuits. **PK** I can adapt my teaching style	**Factual Knowledge** "At the end of the session, the students should be able to googling about electric circuit diagram to confirm their view". **Conceptual Knowledge** "At the end of the session, the students should be able to retrieve function of electric components used in electric

Locating/Finding, Bullet pointing, highlighting, **Action Verb for digital taxonomy:** Bookmarking, Social networking, Social bookmarking, Searching, googling,	Graphics tools Chat rooms Email Discussion boards **Bookmarking** internet browsers web 2.0 tools **Social Networking** – Facebook Myspaces Instagram Google + **Basic Searches** – Search engines Google, Yahoo	according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students' ability to recall knowledge about an electric circuit. **TCK** I know about technologies that I can use to provide an opportunity for learners' for retrieving knowledge about electric currents. **TPK** I can choose technologies that enhance the teaching approaches to make students able to recognize different aspects of an electric circuit. **TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching approaches	circuit diagram". **Procedural Knowledge** "At the end of the session, the students should be able to web publishing a video about making of simple torch recalling the required electric circuit diagram". **Metacognitive Knowledge** "At the end of this session, the students should be able to list ing their views about working of the electric circuit on their Facebook pages.

2. Understanding: This objective can be achieved by constructing meaning from the decoding of symbolic information or descriptive information from different types of verbal or visual sources.

Table 2: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Understanding level of Bloom's taxonomy

Action Verbs	**Digital Activities**	**Knowledge type and checklist for self-reflection about expertise in related knowledge type**	**Learning objective** **Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective**
Traditional Action Verb: Interpreting, Exemplifying, Summarising, Inferring, Paraphrasing, Classifying, Comparing, Explaining **Action Verb for digital taxonomy:** commenting, annotating, blog journalling, twittering, categorizing and tagging, subscribing Advanced searches, boolean searches	**Recitation** Mind map, flashcards, presentation tools **Summary Collection Explanation** Web page, Mind map, web publishing blog journals & simple page construction collaborative documents, wiki **Show and tell** Web Pages, presentation – online & desktop-based, graphics, audio tools audacity sound recorder & podcasting tools, video tools, Mind map) **List/Label** Web Pages, Mind map, Graphics, online tools – ajax drag **Advanced and boolean searches**	**TK** I know about a lot of different technologies to explain electrodynamics to learners. **CK** I have a sufficient understanding of the electric current and electric circuit. **PK** I can adapt my teaching style according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students' ability to summarize knowledge about electric current and circuit. **TCK** I know about technologies that I can use to provide an opportunity for learners' for explaining knowledge about electric currents.	**Factual Knowledge** "At the end of the session, the students should be able to summarize web pages information about the electric circuit". **Conceptual Knowledge** "At the end of the session, the students should be able to comment on the functioning of different electric components used in electric circuit diagram". **Procedural Knowledge** "At the end of the session, the students should be able to tag video content in social media showing bulb glow with indicating the direction of flow of the electric current". **Metacognitive Knowledge** "At the end of this session, the students should be able to make advanced searches in the google search engine about the

	advanced search features - google etc **Blog journalling** - Bloglines, blogger, etc **Diary/Journal** blogging, Myspaces, Facebook, Bloglines, blogger) **Categorizing and Tagging, comments annotating** - noticeboards, discussion boards, threaded discussions, adobe acrobat reader, blog readers, firefox, Facebook	**TPK** I can choose technologies that enhance the teaching approaches to make students able to comment on different aspects of the electric circuit. **TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching.approaches.	idea of electric current flow and heating of wire after correlated it with their prior concept about it".

3. Applying: This objective can be achieved using a theory, principle or procedure to solve a problem involving a new or unfamiliar situation.

Table 3: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Applying level of Bloom's taxonomy

Action Verb	**Digital Activities**	**Knowledge type and checklist for self-reflection about expertise in related knowledge type**	**Learning objective** **Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective**
Traditional Action verb: Implementing Carrying out Using Executing Doing, **Action Verb for digital taxonomy:** running, loading, playing, operating, hacking, uploading, sharing, editing	**Performance** Powerpoint Show, collaboration using tools Podcast, vodcast, the film, audio and video conferencing, VoIP, audio recording, speech,) **Editing** - video and sound tools **Playing** – online games, simulations **Illustration** Paint, online tools, Comic creation tools – comic life Corel, Inkscape, **Simulation** Graphic tools, Google Sketchup, Crocodile software, simulating science experiments **Sculpture or Demonstration** screen capture, Presentation, graphics, audio and video conferencing **Presentation** - Impress, Powerpoint, Google presentation, Skype, Interactive whiteboard collaboration using e-tools, audio and video	**TK** I know about a lot of different technologies to share problem-solving skills in electrodynamics to learners. **CK** I have sufficient in-depth knowledge about electric current and electric circuits. **PK** I can adapt my teaching style according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students' ability to solve problems related to electric current and circuit. **TCK** I know about technologies that I can use to provide an opportunity for learners' to solve basic problems related to electric circuits. **TPK** I can choose technologies that enhance the teaching approaches to make students able to executing problem-solving processes in basic electrodynamics.	**Factual Knowledge** "At the end of the session, the students should be able to perform PowerPoint show to label different electric components in household electric circuit". **Conceptual Knowledge** "At the end of the session, the students should be able to use simulating science experiments to making different combinations of cells in an electric circuit". **Procedural Knowledge** "At the end of the session, the students should be able to upload video content in social media which relate glowing of the torch with a closed electric circuit". **Metacognitive Knowledge** "At the end of this session, the students should be able to take part in an audio-video conference for sharing information about different heating elements works due to current electricity".

	conferencing **Interview** Mind mapper, podcast, vodcast, audacity, sound recorder, collaboration using tools, Skype	**TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching approaches.	

4. Analyzing: Differentiating or breaking elements, relationship or organizational principles for determining how the parts interrelate to each other.

Table 4: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Analyzing level of Bloom's taxonomy

Action Verb	**Digital Activities**	**Knowledge type and checklist for self-reflection about expertise in related knowledge type**	**Learning objective** **Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective**
Traditional Action Verb: Comparing, Organizing, Deconstructing, Attributing, Outlining, Structuring, **Action Verb for digital taxonomy:** Integrating, Mashing, linking, reverse-engineering, cracking, mind-mapping, validating	**Survey** Web-based tools – embedded polls and votes, social networking tools, etc, Spreadsheet, email, discussion boards, cellphones, and texting **Relationship mind maps** - SWOT Analysis, Kidspiration, smart ideas, Cmap, Freemind Online tools **Database** databases using MySQL and Access, wikis GIS - Google earth, Google Maps, Flickr **Abstract** Web publishing **Checklist** Survey tools, online polls, Spreadsheet) **Chart** (Spreadsheet, digitizer, mind mapping tools online tools -	**TK** I know about a lot of different technologies to make learners able to organizing knowledge about electrodynamics. **CK** I have sufficient in-depth knowledge about electric current and electric circuits. **PK** I can adapt my teaching style according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students able to structuring electric circuits with varying electric components. **TCK** I know about technologies that I can use to provide an opportunity for learners' to outline knowledge about electric circuits. **TPK** I can choose technologies that enhance the teaching approaches to make students able to describing every minute detail of the electric circuit. **TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching approaches.	**Factual Knowledge** "At the end of the session, the students should be able to compare functions of different electric components in a household electric circuit to prepare database". **Conceptual Knowledge** "At the end of the session, the students should be able to use online graphic tools for structuring different combinations of cells in an electric circuit". **Procedural Knowledge** "At the end of the session, the students should be able to use an online discussion forum for identifying problems in the electric circuit/components, if the bulb does not glow. **Metacognitive Knowledge** "At the end of this session, the students should be able to blogging about the comparison of different heating elements due to an electric current".

5.Evaluating: This objective can be achieved with help of making judgment in terms of internal or external criticism.

Table 5: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Evaluating level of Bloom's taxonomy

Action Verbs	Digital Activities	Knowledge type and checklist for self-reflection about expertise in related knowledge type	Learning objective Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective
Traditional Action Verb: Checking, Hypothesising, Critiquing, Experimenting, Judging, Testing, Detecting, **Action Verb for digital taxonomy:** Monitoring (Blog/vlog), commenting, reviewing, posting, moderating, collaborating, networking, reflecting, (Alpha & beta) testing.	**Debate** **Panel** sound recorder, podcasting or vodcasting, Mind mapping - inspiration, Chatrooms, IM, email, discussion boards, video, and Phone conferencing (skype, IM) Collaboration tools – Elluminate, etc.) **Report** web-published – Report, blog entry, wiki entry, web page, DTP, Presentation, Camera) **Evaluation** **Investigation** web-published –report blog entry, wiki entry, web page, camera, Internet, Online tools, camera, GIS[Google earth, Google Maps, Flickr **Commenting, moderating reviewing posting - Collaborating Networking** discussion boards, forums, blog, wiki's, twitter, threaded discussions, bulletin boards, chatrooms, video conferencing, chatrooms, instant messaging, text messaging, video messaging audio conferencing	**TK** I know about a lot of different technologies to express learners to check any fault in an electric circuit. **CK** I have sufficient in-depth knowledge about electric current and electric circuits. **PK** I can adapt my teaching style according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students able to distinguishing different electric circuits based on varying characteristics of different electric components. **TCK** I know about technologies that I can use to provide an opportunity for learners' to provide value judgment about features of electric circuits. **TPK** I can choose technologies that enhance the teaching approaches to make students able to the testing problem in an electric circuit. **TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching approaches.	**Factual Knowledge** "At the end of the session, the students should be able to make a blog entry about the judgment of using copper wire in an electric circuit. **Conceptual Knowledge** "At the end of the session, the students should be able to test glowing bulb in an electric circuit using parallel and series combinations of cells in a Facebook live session". **Procedural Knowledge** "At the end of the session, the students should be able to make an online discussion to use suitable electric cell and bulb from a given assemblage for making torch by checking their specifications". **Metacognitive Knowledge** "At the end of this session, the students should be able to reflect in chatrooms about the heating effect on different materials due to an electric current".

6.Creating: This objective can be achieved with the ability to produce unique communication, a plan or a proposed set of operations. Derivation of a set of abstract relations needed for creating.

Table 6: Action verbs, digital activities, physics teachers' TPACK skills and learning objectives for Creating level of Bloom's taxonomy

Action Verbs	**Digital Activities**	**Knowledge type and checklist for self-reflection about expertise in related knowledge type**	**Learning objective** **Time Frame + Student focus +Action Verb + Product/process/outcome = Learning objective**
Traditional Action Verb: Designing, Constructing, Planning, Producing, Inventing, Devising, Making, Building **Action Verb for digital taxonomy:** Programming, Filming, Animating, Blogging, Video Blogging, Mixing, Remixing, Wiki-ing, Publishing, Videocasting, Podcasting, Directing/producing	**Film** Moviemaker, Pinnacle Studio, Adobe premier elements **Presentation/ Story** presentation tools - Powerpoint, Impress, Photostory, Google present. Comic creation tools – comic life, hyper comic, online tools **Project / Plan** calendars, flow charts [inspiration, Freemind, C-Map, smartideas], mind maps) **Blogging /video blogging** - Blogging tool, blogger, WordPress, edublogs, classroom blog meister, Bloglines **Vodcast, podcast videocasting screen casting** voice thread, blogging tool, skype, collaboration and classroom tools – elluminate, live classroom	**TK** I know about a lot of different technologies to prepare learners for designing different electric circuits. **CK** I have sufficient in-depth knowledge about electric current and electric circuits. **PK** I can adapt my teaching style according to the need of different learners. **PCK** I know how to select effective teaching methods/approaches to make students able to building a household electric circuit model. **TCK** I know about technologies that I can use to provide an opportunity for learners' share steps of the working model to peer-group via social media. **TPK** I can choose technologies that enhance the teaching approaches to make students able to the testing problem in an electric circuit. **TPACK** I can teach lessons that appropriately combine physics, technologies, and teaching approaches.	**Factual Knowledge** "At the end of the session, the students should be able to blogging about different factors associated with the function of electric components in an electric circuit". **Conceptual Knowledge** "At the end of the session, the students should be able to present a photostory of to glowing bulb in an electric circuit using parallel and series combinations of cells". **Procedural Knowledge** "At the end of the session, the students should be able to make an animated video film about modification of the structure of the electric circuit of a simple torch/making a device using simple electric circuit". **Metacognitive Knowledge** "At the end of this session, the students should be able to present their views on social media about their logic on minimal energy loss due to heat in current-carrying electric circuit".

III. CONCLUSION

In modern education system technology is the most controversial topic because there is a big gap between traditional and modern educational practices due to the inclusion of digital tools and techniques. It is challenging to prepare a teacher who can use technology in the classroom situation parallel with his pedagogical skills and content knowledge. For this complexity which can be seen in the administration of the TPACK framework in the classroom situation, teachers should make self-reflection on their preparedness for performing under this framework. In this paper, the researcher has suggested self-reflective statements each for seven elements of the TPACK framework on which a teacher should reflect their experience before work on this framework. Technology-enabled teaching-learning sessions should have digital taxonomy in place of traditional taxonomy which fails to suggest digital products needed at any one stage of progress in taxonomy. However, this study limited to physics subject teachers and content but it can be used to improve and facilitate instruction in other subjects also.

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