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Redesign of Technological Pedagogical Science Knowledge based on Local Culture

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***Abstract*—This research is a literature study and the method used is Systematic Literature Review (SLR). The advancement of the educational world demands a renewal of knowledge and skills in accordance with the demands of the development of 21st century education. Teachers must be able to integrate between content, pedagogy, and technology by lifting culture local in classroom learning practices. Local culture-based learning is used by teachers who must be adapted to the subject matter presented under the curriculum. The important thing here is how students are able to understand and master the concept of science through local culture using current technology. The design of the learning model begins with a redesign of TPSK integration indicators. Redesign of Technological Pedagogical Science Knowledge (TPSK) Based on existing Local Culture can be used by teachers as a reference in developing learning model that integrates technology, pedagogy, knowledge. TPSK in science learning should be tailored to the needs and facilities available in schools.**

Keyword*—*redesign, tpsk, local culture.

I. BACKGROUND

Currently the demands in the world of education, students must be equipped with the science in accordance with the development of 21st century education. This becomes one of the teacher's task that is part of the professionalism of a teacher. Koehler, *et al*. in [1] stated that the teacher's professional ability implies the content, pedagogy, and technology he possesses. The use of technology in science learning is emphasized to science teachers who are adapted to meaningful pedagogical frameworks in learning materials [2] and are expected to assist students in learning science [3].

The integration of content, pedagogy, and technology is packaged in Technological Pedagogical Content Knowledge (TPACK). The TPACK is currently regarded as an essential framework for promoting instructional competence of 21st century teachers [4]. One of the challenges of 21st century education is finding and developing efficient tools for learning. Therefore, a teacher needs to know the foundation in utilizing computer technology to be used in teaching. Teachers need to apply local culture-based learning using technology. Technology as a powerful tool for changing classroom teaching practices that are considered effective. In line with Awolaju's in [5] opinion, Abdu-Raheem in [6], Musa and Agwagah in [7] which states that projected learning using media will be better than without projected using instructional media.

Effective learning practices contribute to the quality of learning. According to Chen, Hendricks, & Archibald in [8] quality teaching practices need to apply appropriate strategies, make use of comprehensible language, encourage learners' engagement, and be responsive to the needs of learners. Teachers and learners can use new technologies to collect, organize, and evaluate information to solve problems and innovate practical ideas in the real world [9]; [10]. According to Jimoyiannis in [10] Information and Communication Technology (ICT) is deemed inherent to the educational reform effort needed for 21st century society that can produce fundamental changes. Particularly in ICT-based science learning is potentially and highly effective as they provide opportunities for active learning, enabling learners to have higher cognitive levels, support constructive learning, and promote scientific inquiry and conceptual change. TPACK for science teachers according to Angeli & Valanides in [11] and Jimoyiannis in [10] includes knowledge of representation, science curriculum, learners' understanding of science, various educational contexts, ICT tools capabilities, etc.

Implementation of education according to what the 21st century education aspires is not as easy as imagined. There are still some things that become obstacles in practice in the world of education today. In general, teachers recognize the importance of introducing ICTs in the learning process, but teachers tend to be less in applying ICT in the classroom and less sure of their potential to improve the learning process [12]; [13] This is in line with the views of Mumtaz [14] and Afshari, *et al*. in [15] which state that teachers' lack of knowledge and trust in the use of ineffective technology in the classroom, along with common problems such as lack of good technological tools.

Teachers tend to use ICTs for the sake of academic tasks such as searching for information on the internet or for administrative purposes e.g. looking for examples of learning tools, etc. rather than being used as a classroom learning tool [13]. The ICT development tends to focus on the technological aspects of how to use various tools in learning while pedagogical and instructional problems are why and how the tools can be used to enhance learning are often considered ordinary or under-noticed.

The rest of this paper is organized as follow: Section II describes proposed research method of this work. Section III presents the obtained results and following by discussion IV. Finally, Section V concludes this work.

II. PROPOSED METHOD

The method used in this research is Systematic Literature Review (SLR) which according to Mulrow in [16]

is one of scientific activities. This research is conducted by conducting systematic literature review by taking and integrating existing information. The resulting information integration results are then used to provide direction for the study effectively. A systematic literature review is used to (a) define, rationalize, and revise predetermined hypotheses, (b) understand and minimize previous assignments, (c) obtain estimates of numbers, and (d) identify important confounding effects and necessary covariates considered in future studies [16]. Literature can be analyzed in six components of interest i.e. the database is used to retrieve articles, theoretical perspectives used to conduct systematic integrated literature review, quality assessment tools, integration tables and contents, methods used to categorize articles, and methods used to synthesize findings which is obtained.

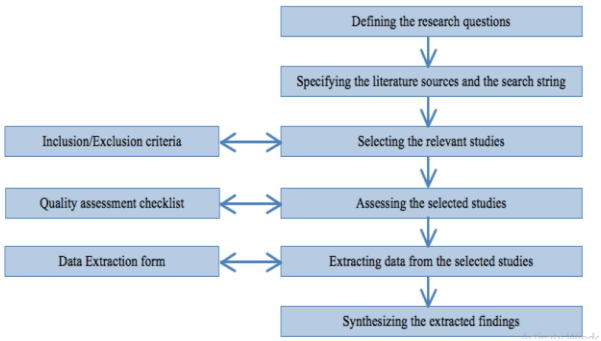

Fig. 1. Systematic Literature Review Sceme

III. RESULTS AND DISCUSSION

TPACK in Local Science-Based Science Learning

Learning of the 21st century has launched significant changes in learning methods by involving students in every learning activity. In an effort to create sophisticated learning today, teachers should be able to act as facilitators who provide the greatest opportunities for students to express themselves in the learning process. TPACK is an integration of content, pedagogy, and technology. According to Rosenberg and Koehler in [17] there are still most who do not fully understand about TPACK. Koehler found an interest in something unique: the overlap between technology, pedagogical, content, and knowledge. The uniqueness is the inclusion to provide a unified experience in which a teacher can combine their knowledge with more specific content and then how to effectively teach the content (pedagogy) as well as what technology is used to provide an effective learning experience to learners.

According to the results of the survey proposed by O'Bannon and Thomas [18] found that preservice teachers recognize and use more features of smartphone, but they are not enthusiastic about using smartphones in learning. Further development, not limited to here but the use of technology must be integrated in learning between technology, pedagogic, content and knowledge. The purpose of this integration for future teacher education. This is in line with the opinion of Jen, *et al*. in [19] which suggests that not only how well teachers can teach with technology, but also a constructive direction for future teacher education. Niess, *et al*. in [20] argues that TPACK development of teachers usually begins by recognizing technology in learning and shaping attitudes and beliefs in accepting their values, especially when teachers motivate learners by providing technically supported instruction or properly guided in learning with using a particular technology.

Research on TPACK has previously been done focusing on content coverage and grade level with respect to practice [21] development of instrument measurement [22], teacher [23], focusing on theory [24], and research was undertaken at higher education [25], as well as further research into the processes and products of TPACK's leadership diagnostic tool [25]. Currently seven TPACK construction components namely TK, PK, CK, TPK, TCK, PCK, and TPACK have been studied by educational technology researchers such as Angeli, *et al*. in [26]; Brantley-Dias & Ertmer in [27]; Voogt, *et al*. in [28]. They do research on TPACK by dividing it into seven components which then inter-component integrate into TPACK.

In addition, previous research has been done Aktas & Yurt in [29] which is about the influence of learning using digital story which gives effect of positive influence to the level of academic achievement of learners. This is also in line with many studies in the literature which show that digital storytelling in learning can increase the academic achievement level of learners because it allows them to conduct individual research, actively participate in learning and learning processes through experience [30], [32], [33] [34], [35], [36]; [37]; [38]; [39]; [40]. This proves that many have done research related to TPACK and success.

Research conducted Sato and Haegele in [41] stated that the involvement of educators in the online physical adaptation of professional development graduate education resulted that with the presence of instructors online, it can change their teaching style (pedagogical orientation). This suggests that instructions given online can be understood and performed by observers. Local science-based science learning is the creation of a learning environment and the design of a science-learning experience that integrates local culture as part of the learning process of science. In the process of learning based on local culture, it means that culture is integrated as a tool in the learning process.

Figure 2 describes the integration matrix of PSK and TSK. Meanwhile, Figure 3 depicts the integration matrix of PTSK and TPK.

PPhyK		TPhyK																						
		1									2			3							4			
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
I	A	IA1a	IA1b	IA1c	IA1d	IA1e	IA1f	IA1g	IA1h	IA1i	IA2j	IA2k	IA2l	IA3m	IA3n	IA3o	IA3p	IA3q	IA3r	IA3s	IA4t	IA4u	IA4v	IA4w
	B	IB1a	IB1b	IB1c	IB1d	IB1e	IB1f	IB1g	IB1h	IB1i	IB2j	IB2k	IB2l	IB3m	IB3n	IB3o	IB3p	IB3q	IB3r	IB3s	IB4t	IB4u	IB4v	IB4w
	C	IC1a	IC1b	IC1c	IC1d	IC1e	IC1f	IC1g	IC1h	IC1i	IC2j	IC2k	IC2l	IC3m	IC3n	IC3o	IC3p	IC3q	IC3r	IC3s	IC4t	IC4u	IC4v	IC4w
	D	ID1a	ID1b	ID1c	ID1d	ID1e	ID1f	ID1g	ID1h	ID1i	ID2j	ID2k	ID2l	ID3m	ID3n	ID3o	ID3p	ID3q	ID3r	ID3s	ID4t	ID4u	ID4v	ID4w
	E	IE1a	IE1b	IE1c	IE1d	IE1e	IE1f	IE1g	IE1h	IE1i	IE2j	IE2k	IE2l	IE3m	IE3n	IE3o	IE3p	IE3q	IE3r	IE3s	IE4t	IE4u	IE4v	IE4w
II	F	IIF1a	IIF1b	IIF1c	IIF1d	IIF1e	IIF1f	IIF1g	IIF1h	IIF1i	IIF2j	IIF2k	IIF2l	IIF3m	IIF3n	IIF3o	IIF3p	IIF3q	IIF3r	IIF3s	IIF4t	IIF4u	IIF4v	IIF4w
	G	IIG1a	IIG1b	IIG1c	IIG1d	IIG1e	IIG1f	IIG1g	IIG1h	IIG1i	IIG2j	IIG2k	IIG2l	IIG3m	IIG3n	IIG3o	IIG3p	IIG3q	IIG3r	IIG3s	IIG4t	IIG4u	IIG4v	IIG4w
	H	IIH1a	IIH1b	IIH1c	IIH1d	IIH1e	IIH1f	IIH1g	IIH1h	IIH1i	IIH2j	IIH2k	IIH2l	IIH3m	IIH3n	IIH3o	IIH3p	IIH3q	IIH3r	IIH3s	IIH4t	IIH4u	IIH4v	IIH4w
	I	III1a	III1b	III1c	III1d	III1e	III1f	III1g	III1h	III1i	III2j	III2k	III2l	III3m	III3n	III3o	III3p	III3q	III3r	III3s	III4t	III4u	III4v	III4w
III	J	IIIJ1a	IIIJ1b	IIIJ1c	IIIJ1d	IIIJ1e	IIIJ1f	IIIJ1g	IIIJ1h	IIIJ1i	IIIJ2j	IIIJ2k	IIIJ2l	IIIJ3m	IIIJ3n	IIIJ3o	IIIJ3p	IIIJ3q	IIIJ3r	IIIJ3s	IIIJ4t	IIIJ4u	IIIJ4v	IIIJ4w
	K	IIIK1a	IIIK1b	IIIK1c	IIIK1d	IIIK1e	IIIK1f	IIIK1g	IIIK1h	IIIK1i	IIIK2j	IIIK2k	IIIK2l	IIIK3m	IIIK3n	IIIK3o	IIIK3p	IIIK3q	IIIK3r	IIIK3s	IIIK4t	IIIK4u	IIIK4v	IIIK4w
	L	IIIL1a	IIIL1b	IIIL1c	IIIL1d	IIIL1e	IIIL1f	IIIL1g	IIIL1h	IIIL1i	IIIL2j	IIIL2k	IIIL2l	IIIL3m	IIIL3n	IIIL3o	IIIL3p	IIIL3q	IIIL3r	IIIL3s	IIIL4t	IIIL4u	IIIL4v	IIIL4w
	M	IIIM1a	IIIM1b	IIIM1c	IIIM1d	IIIM1e	IIIM1f	IIIM1g	IIIM1h	IIIM1i	IIIM2j	IIIM2k	IIIM2l	IIIM3m	IIIM3n	IIIM3o	IIIM3p	IIIM3q	IIIM3r	IIIM3s	IIIM4t	IIIM4u	IIIM4v	IIIM4w
IV	N	IVN1a	IVN1b	IVN1c	IVN1d	IVN1e	IVN1f	IVN1g	IVN1h	IVN1i	IVN2j	IVN2k	IVN2l	IVN3m	IVN3n	IVN3o	IVN3p	IVN3q	IVN3r	IVN3s	IVN4t	IVN4u	IVN4v	IVN4w
	O	IVO1a	IVO1b	IVO1c	IVO1d	IVO1e	IVO1f	IVO1g	IVO1h	IVO1i	IVO2j	IVO2k	IVO2l	IVO3m	IVO3n	IVO3o	IVO3p	IVO3q	IVO3r	IVO3s	IVO4t	IVO4u	IVO4v	IVO4w
	P	IVP1a	IVP1b	IVP1c	IVP1d	IVP1e	IVP1f	IVP1g	IVP1h	IVP1i	IVP2j	IVP2k	IVP2l	IVP3m	IVP3n	IVP3o	IVP3p	IVP3q	IVP3r	IVP3s	IVP4t	IVP4u	IVP4v	IVP4w
	Q	IVQ1a	IVQ1b	IVQ1c	IVQ1d	IVQ1e	IVQ1f	IVQ1g	IVQ1h	IVQ1i	IVQ2j	IVQ2k	IVQ2l	IVQ3m	IVQ3n	IVQ3o	IVQ3p	IVQ3q	IVQ3r	IVQ3s	IVQ4t	IVQ4u	IVQ4v	IVQ4w
	R	IVR1a	IVR1b	IVR1c	IVR1d	IVR1e	IVR1f	IVR1g	IVR1h	IVR1i	IVR2j	IVR2k	IVR2l	IVR3m	IVR3n	IVR3o	IVR3p	IVR3q	IVR3r	IVR3s	IVR4t	IVR4u	IVR4v	IVR4w
V	S	VS1a	VS1b	VS1c	VS1d	VS1e	VS1f	VS1g	VS1h	VS1i	VS2j	VS2k	VS2l	VS3m	VS3n	VS3o	VS3p	VS3q	VS3r	VS3s	VS4t	VS4u	VS4v	VS4w
	T	VT1a	VT1b	VT1c	VT1d	VT1e	VT1f	VT1g	VT1h	VT1i	VT2j	VT2k	VT2l	VT3m	VT3n	VT3o	VT3p	VT3q	VT3r	VT3s	VT4t	VT4u	VT4v	VT4w
	U	VU1a	VU1b	VU1c	VU1d	VU1e	VU1f	VU1g	VU1h	VU1i	VU2j	VU2k	VU2l	VU3m	VU3n	VU3o	VU3p	VU3q	VU3r	VU3s	VU4t	VU4u	VU4v	VU4w
	V	VV1a	VV1b	VV1c	VV1d	VV1e	VV1f	VV1g	VV1h	VV1i	VV2j	VV2k	VV2l	VV3m	VV3n	VV3o	VV3p	VV3q	VV3r	VV3s	VV4t	VV4u	VV4v	VV4w
	W	VW1a	VW1b	VW1c	VW1d	VW1e	VW1f	VW1g	VW1h	VW1i	VW2j	VW2k	VW2l	VW3m	VW3n	VW3o	VW3p	VW3q	VW3r	VW3s	VW4t	VW4u	VW4v	VW4w
	X	VX1a	VX1b	VX1c	VX1d	VX1e	VX1f	VX1g	VX1h	VX1i	VX2j	VX2k	VX2l	VX3m	VX3n	VX3o	VX3p	VX3q	VX3r	VX3s	VX4t	VX4u	VX4v	VX4w
	Y	VY1a	VY1b	VY1c	VY1d	VY1e	VY1f	VY1g	VY1h	VY1i	VY2j	VY2k	VY2l	VY3m	VY3n	VY3o	VY3p	VY3q	VY3r	VY3s	VY4t	VY4u	VY4v	VY4w
VI	Z	VIZ1a	VIZ1b	VIZ1c	VIZ1d	VIZ1e	VIZ1f	VIZ1g	VIZ1h	VIZ1i	VIZ2j	VIZ2k	VIZ2l	VIZ3m	VIZ3n	VIZ3o	VIZ3p	VIZ3q	VIZ3r	VIZ3s	VIZ4t	VIZ4u	VIZ4v	VIZ4w
	@	VI@1a	VI@1b	VI@1c	VI@1d	VI@1e	VI@1f	VI@1g	VI@1h	VI@1i	VI@2j	VI@2k	VI@2l	VI@3m	VI@3n	VI@3o	VI@3p	VI@3q	VI@3r	VI@3s	VI@4t	VI@4u	VI@4v	VI@4w
	#	VI#1a	VI#1b	VI#1c	VI#1d	VI#1e	VI#1f	VI#1g	VI#1h	VI#1i	VI#2j	VI#2k	VI#2l	VI#3m	VI#3n	VI#3o	VI#3p	VI#3q	VI#3r	VI#3s	VI#4t	VI#4u	VI#4v	VI#4w
VII	$	VII$1a	VII$1b	VII$1c	VII$1d	VII$1e	VII$1f	VII$1g	VII$1h	VII$1i	VII$2j	VII$2k	VII$2l	VII$3m	VII$3n	VII$3o	VII$3p	VII$3q	VII$3r	VII$3s	VII$4t	VII$4u	VII$4v	VII$4w
	%	VII%1a	VII%1b	VII%1c	VII%1d	VII%1e	VII%1f	VII%1g	VII%1h	VII%1i	VII%2j	VII%2k	VII%2l	VII%3m	VII%3n	VII%3o	VII%3p	VII%3q	VII%3r	VII%3s	VII%4t	VII%4u	VII%4v	VII%4w
	&	VII&1a	VII&1b	VII&1c	VII&1d	VII&1e	VII&1f	VII&1g	VII&1h	VII&1i	VII&2j	VII&2k	VII&2l	VII&3m	VII&3n	VII&3o	VII&3p	VII&3q	VII&3r	VII&3s	VII&4t	VII&4u	VII&4v	VII&4w
	*	VII*1a	VII*1b	VII*1c	VII*1d	VII*1e	VII*1f	VII*1g	VII*1h	VII*1i	VII*2j	VII*2k	VII*2l	VII*3m	VII*3n	VII*3o	VII*3p	VII*3q	VII*3r	VII*3s	VII*4t	VII*4u	VII*4v	VII*4w

Figure 2. Integration Matrix of PSK with TSK

	IIIJ1a 1)i	IIIJ1b 1)ii	IIIJ1c 1)iii	IIIJ1d 1)iv	IIIJ1e 2)v	IIIJ1f 2)vi	IIIJ1g 2)vii	IIIJ1h 2)viii	IIIJ1i 3)ix	IIIJ2j 3)x	IIIJ2k 3)xi	IIIJ2l 4)xii	IIIJ3 m4)x iii	IIIJ3n 5)xiv	IIIJ3o 5)xv	IIIJ3p 5)xvi	IIIJ3q5) xvii	IIIJ3r 6)xvii i	IIIJ3s 6)xix	IIIJ4t 6)xx	IIIJ4u 6)xxi	IIIJ4v 6)xxii	IIIJ4 w6)x xiii
	IIIK1 a1)i	IIIK1 b1)ii	IIIK1 c1)iii	IIIK1 d1)iv	IIIK1 e2)v	IIIK1f 2)vi	IIIK1 g2)vii	IIIK1 h2)vi ii	IIIK1i 3)ix	IIIK2j 3)x	IIIK2 k3)xi	IIIK2l 4)xii	IIIK3 m4)x iii	IIIK3 n5)xi v	IIIK3 o5)x v	IIIK3 p5)x vi	IIIK3q5)xvii	IIIK3r 6)xvii i	IIIK3s 6)xix	IIIK4t 6)xx	IIIK4 u6)x xi	IIIK4 v6)xx ii	IIIK4 w6)x xiii
	IIIL1a 1)i	IIIL1 b1)ii	IIIL1c 1)iii	IIIL1 d1)iv	IIIL1e 2)v	IIIL1f 2)vi	IIIL1g 2)vii	IIIL1 h2)vi ii	IIIL1i 3)ix	IIIL2j 3)x	IIIL2k 3)xi	IIIL2l 4)xii	IIIL3 m4)x iii	IIIL3 n5)xi v	IIIL3 o5)x v	IIIL3 p5)x vi	IIIL3q5) xvii	IIIL3r 6)xvii i	IIIL3s 6)xix	IIIL4t 6)xx	IIIL4 u6)x xi	IIIL4v 6)xxii	IIIL4 w6)x xiii
	IIIM1 a1)i	IIIM1 b1)ii	IIIM1 c1)iii	IIIM1 d1)iv	IIIM1 e2)v	IIIM1 f2)vi	IIIM1 g2)vii	IIIM1 h2)vi ii	IIIM1 i3)ix	IIIM2 j3)x	IIIM2 k3)xi	IIIM2 l4)xii	IIIM3 m4)x iii	IIIM3 n5)xi v	IIIM3 o5)x v	IIIM3 p5)x vi	IIIM3q 5)xvii	IIIM3 r6)xv iii	IIIM3 s6)xi x	IIIM4 t6)xx	IIIM4 u6)x xi	IIIM4 v6)xx ii	IIIM4 w6)x xiii
	IVN1 a1)i	IVN1 b1)ii	IVN1 c1)iii	IVN1 d1)iv	IVN1 e2)v	IVN1 f2)vi	IVN1 g2)vii	IVN1 h2)vi ii	IVN1 i3)ix	IVN2 j3)x	IVN2 k3)xi	IVN2 l4)xii	IVN3 m4)x iii	IVN3 n5)xi v	IVN3 o5)x v	IVN3 p5)x vi	IVN3q5)xvii	IVN3 r6)xv iii	IVN3 s6)xi x	IVN4 t6)xx	IVN4 u6)x xi	IVN4 v6)xx ii	IVN4 w6)x xiii
	IVO1 a1)i	IVO1 b1)ii	IVO1 c1)iii	IVO1 d1)iv	IVO1 e2)v	IVO1 f2)vi	IVO1 g2)vii	IVO1 h2)vi ii	IVO1 i3)ix	IVO2 j3)x	IVO2 k3)xi	IVO2 l4)xii	IVO3 m4)x iii	IVO3 n5)xi v	IVO3 o5)x v	IVO3 p5)x vi	IVO3q5)xvii	IVO3 r6)xv iii	IVO3 s6)xi x	IVO4 t6)xx	IVO4 u6)x xi	IVO4 v6)xx ii	IVO4 w6)x xiii
	IVP1 a1)i	IVP1 b1)ii	IVP1 c1)iii	IVP1 d1)iv	IVP1 e2)v	IVP1f 2)vi	IVP1 g2)vii	IVP1 h2)vi ii	IVP1i 3)ix	IVP2j 3)x	IVP2 k3)xi	IVP2l 4)xii	IVP3 m4)x iii	IVP3 n5)xi v	IVP3 o5)x v	IVP3 p5)x vi	IVP3q5)xvii	IVP3r 6)xvii i	IVP3 s6)xi x	IVP4t 6)xx	IVP4 u6)x xi	IVP4 v6)xx ii	IVP4 w6)x xiii
	IVQ1 a1)i	IVQ1 b1)ii	IVQ1 c1)iii	IVQ1 d1)iv	IVQ1 e2)v	IVQ1 f2)vi	IVQ1 g2)vii	IVQ1 h2)vi ii	IVQ1 i3)ix	IVQ2 j3)x	IVQ2 k3)xi	IVQ2 l4)xii	IVQ3 m4)x iii	IVQ3 n5)xi v	IVQ3 o5)x v	IVQ3 p5)x vi	IVQ3q5)xvii	IVQ3 r6)xv iii	IVQ3 s6)xi x	IVQ4 t6)xx	IVQ4 u6)x xi	IVQ4 v6)xx ii	IVQ4 w6)x xiii
	IVR1 a1)i	IVR1 b1)ii	IVR1 c1)iii	IVR1 d1)iv	IVR1 e2)v	IVR1f 2)vi	IVR1 g2)vii	IVR1 h2)vi ii	IVR1i 3)ix	IVR2j 3)x	IVR2 k3)xi	IVR2l 4)xii	IVR3 m4)x iii	IVR3 n5)xi v	IVR3 o5)x v	IVR3 p5)x vi	IVR3q5)xvii	IVR3 r6)xv iii	IVR3 s6)xi x	IVR4 t6)xx	IVR4 u6)x xi	IVR4 v6)xx ii	IVR4 w6)x xiii
	VS1a 1)i	VS1b 1)ii	VS1c 1)iii	VS1d 1)iv	VS1e 2)v	VS1f 2)vi	VS1g 2)vii	VS1h 2)viii	VS1i 3)ix	VS2j 3)x	VS2k 3)xi	VS2l 4)xii	VS3 m4)x iii	VS3n 5)xiv	VS3o 5)xv	VS3p 5)xvi	VS3q5) xvii	VS3r 6)xvii i	VS3s 6)xix	VS4t 6)xx	VS4u 6)xxi	VS4v 6)xxii	VS4 w6)x xiii
	VT1a 1)i	VT1b 1)ii	VT1c 1)iii	VT1d 1)iv	VT1e 2)v	VT1f 2)vi	VT1g 2)vii	VT1h 2)viii	VT1i 3)ix	VT2j 3)x	VT2k 3)xi	VT2l 4)xii	VT3 m4)x iii	VT3n 5)xiv	VT3o 5)xv	VT3p 5)xvi	VT3q5) xvii	VT3r 6)xvii i	VT3s 6)xix	VT4t 6)xx	VT4u 6)xxi	VT4v 6)xxii	VT4 w6)x xiii
	VU1 a1)i	VU1 b1)ii	VU1c 1)iii	VU1 d1)iv	VU1 e2)v	VU1f 2)vi	VU1g 2)vii	VU1 h2)vi ii	VU1i 3)ix	VU2j 3)x	VU2k 3)xi	VU2l 4)xii	VU3 m4)x iii	VU3 n5)xi v	VU3 o5)x v	VU3 p5)x vi	VU3q5) xvii	VU3r 6)xvii i	VU3s 6)xix	VU4t 6)xx	VU4 u6)x xi	VU4v 6)xxii	VU4 w6)x xiii
	VV1a 1)i	VV1b 1)ii	VV1c 1)iii	VV1d 1)iv	VV1e 2)v	VV1f 2)vi	VV1g 2)vii	VV1h 2)viii	VV1i 3)ix	VV2j 3)x	VV2k 3)xi	VV2l 4)xii	VV3 m4)x iii	VV3n 5)xiv	VV3o 5)xv	VV3p 5)xvi	VV3q5) xvii	VV3r 6)xvii i	VV3s 6)xix	VV4t 6)xx	VV4u 6)xxi	VV4v 6)xxii	VV4 w6)x xiii
	VW1 a1)i	VW1 b1)ii	VW1 c1)iii	VW1 d1)iv	VW1 e2)v	VW1 f2)vi	VW1 g2)vii	VW1 h2)vi ii	VW1i 3)ix	VW2 j3)x	VW2 k3)xi	VW2l 4)xii	VW3 m4)x iii	VW3 n5)xi v	VW3 o5)x v	VW3 p5)x vi	VW3q5)xvii	VW3 r6)xv iii	VW3 s6)xi x	VW4 t6)xx	VW4 u6)x xi	VW4 v6)xx ii	VW4 w6)x xiii

	VX1a 1)i	VX1b 1)ii	VX1c 1)iii	VX1d 1)iv	VX1e 2)v	VX1f 2)vi	VX1g 2)vii	VX1h 2)viii	VX1i 3)ix	VX2j 3)x	VX2k 3)xi	VX2l 4)xii	VX3 m4)x iii	VX3n 5)xiv	VX3o 5)xv	VX3p 5)xvi	VX3q5) xvii	VX3r 6)xvii i	VX3s 6)xix	VX4t 6)xx	VX4u 6)xxi	VX4v 6)xxii	VX4 w6)x xiii
	VY1a 1)i	VY1b 1)ii	VY1c 1)iii	VY1d 1)iv	VY1e 2)v	VY1f 2)vi	VY1g 2)vii	VY1h 2)viii	VY1i 3)ix	VY2j 3)x	VY2k 3)xi	VY2l 4)xii	VY3 m4)x iii	VY3n 5)xiv	VY3o 5)xv	VY3p 5)xvi	VY3q5) xvii	VY3r 6)xvii i	VY3s 6)xix	VY4t 6)xx	VY4u 6)xxi	VY4v 6)xxii	VY4 w6)x xiii
	VIZ1 a1)i	VIZ1 b1)ii	VIZ1 c1)iii	VIZ1 d1)iv	VIZ1 e2)v	VIZ1f 2)vi	VIZ1 g2)vii	VIZ1 h2)vi ii	VIZ1i 3)ix	VIZ2j 3)x	VIZ2 k3)xi	VIZ2l 4)xii	VIZ3 m4)x iii	VIZ3 n5)xi v	VIZ3 o5)x v	VIZ3 p5)x vi	VIZ3q5)xvii	VIZ3r 6)xvii i	VIZ3s 6)xix	VIZ4t 6)xx	VIZ4 u6)x xi	VIZ4 v6)xx ii	VIZ4 w6)x xiii
	VI@ 1a1)i	VI@ 1b1)i i	VI@ 1c1)i ii	VI@ 1d1)i v	VI@ 1e2) v	VI@ 1f2)v i	VI@ 1g2) vii	VI@ 1h2) viii	VI@ 1i3)i x	VI@ 2j3)x	VI@ 2k3) xi	VI@ 2l4)x ii	VI@ 3m4) xiii	VI@ 3n5) xiv	VI@ 3o5) xv	VI@ 3p5) xvi	VI@3q 5)xvii	VI@ 3r6)x viii	VI@ 3s6)x ix	VI@ 4t6)x x	VI@ 4u6) xxi	VI@ 4v6) xxii	VI@ 4w6) xxiii
	VI#1 a1)i	VI#1 b1)ii	VI#1 c1)iii	VI#1 d1)iv	VI#1 e2)v	VI#1f 2)vi	VI#1 g2)vii	VI#1 h2)vi ii	VI#1i 3)ix	VI#2j 3)x	VI#2 k3)xi	VI#2l 4)xii	VI#3 m4)x iii	VI#3 n5)xi v	VI#3 o5)x v	VI#3 p5)x vi	VI#3q5)xvii	VI#3r 6)xvii i	VI#3 s6)xi x	VI#4t 6)xx	VI#4 u6)x xi	VI#4 v6)xx ii	VI#4 w6)x xiii
	VII$1 a1)i	VII$1 b1)ii	VII$1 c1)iii	VII$1 d1)iv	VII$1 e2)v	VII$1 f2)vi	VII$1 g2)vii	VII$1 h2)vi ii	VII$1 i3)ix	VII$2 j3)x	VII$2 k3)xi	VII$2 l4)xii	VII$3 m4)x iii	VII$3 n5)xi v	VII$3 o5)x v	VII$3 p5)x vi	VII$3q 5)xvii	VII$3 r6)xv iii	VII$3 s6)xi x	VII$4 t6)xx	VII$4 u6)x xi	VII$4 v6)xx ii	VII$4 w6)x xiii
	VII% 1a1)i	VII% 1b1)i i	VII% 1c1)i ii	VII% 1d1)i v	VII% 1e2) v	VII% 1f2)v i	VII% 1g2) vii	VII% 1h2) viii	VII% 1i3)i x	VII% 2j3)x	VII% 2k3) xi	VII% 2l4)x ii	VII% 3m4) xiii	VII% 3n5) xiv	VII% 3o5) xv	VII% 3p5) xvi	VII%3q 5)xvii	VII% 3r6)x viii	VII% 3s6)x ix	VII% 4t6)x x	VII% 4u6) xxi	VII% 4v6) xxii	VII% 4w6) xxiii
	VII& 1a1)i	VII& 1b1)i i	VII& 1c1)i ii	VII& 1d1)i v	VII& 1e2) v	VII& 1f2)v i	VII& 1g2) vii	VII& 1h2) viii	VII& 1i3)i x	VII& 2j3)x	VII& 2k3) xi	VII& 2l4)x ii	VII& 3m4) xiii	VII& 3n5) xiv	VII& 3o5) xv	VII& 3p5) xvi	VII&3q 5)xvii	VII& 3r6)x viii	VII& 3s6)x ix	VII& 4t6)x x	VII& 4u6) xxi	VII& 4v6) xxii	VII& 4w6) xxiii
	VII*1 a1)i	VII*1 b1)ii	VII*1 c1)iii	VII*1 d1)iv	VII*1 e2)v	VII*1 f2)vi	VII*1 g2)vii	VII*1 h2)vi ii	VII*1 i3)ix	VII*2 j3)x	VII*2 k3)xi	VII*2 l4)xii	VII*3 m4)x iii	VII*3 n5)xi v	VII*3 o5)x v	VII*3 p5)x vi	VII*3q 5)xvii	VII*3 r6)xv iii	VII*3 s6)xi x	VII*4 t6)xx	VII*4 u6)x xi	VII*4 v6)xx ii	VII*4 w6)x xiii

Figure 3. Integration Matrix of PTSK with TPK

From Figures 2 and 3, they can be described as follow:

A. PSK (Pedagogical Science Knowledge)

1. Scientific Knowledge

- Structure of Science
- Facts, Theories, and Practices
- History and Philosophy / Paradigm of Science
- Nature of Science
- Relationship between Science, Technology, and Society

2. Science Curriculum

- General Purpose of Science Education
- Special Learning Objectives for Various Units
- Philosophy of Science Education Curriculum
- Available Resources

3. Transformation of Scientific Knowledge

- Organizing Scientific Knowledge (facts, theories, practices)
- Representation of Scientific Knowledge (images, graphics, vectors, mathematics)
- Teaches Nature of Science
- Teaches Science, Technology and Society

4. Difficulty Learning Students about Certain Fields

- Early Knowledge of Students
- Student Misconception
- Student Cognitive Barriers
- Skill of Scientific Method of Student
- Student Learning Profile

5. Learning Strategy

- Promote student motivation and involvement
- Using practical / experimental work
- Use of Scientific Inquiries
- Use of Scientific Explanations
- The Use of Constructivism Approach
- Use of Cognitive Conflict Situations
- Use of a Conceptual Change Strategy

6. Common Pedagogic

- Knowing Basic Pedagogy
- Developing a Pedagogical Philosophy
- Knowing the Pedagogical Strategy

7. Education Context

- Educational Objectives
- School Culture
- Practical Knowledge
- Knowledge of Class Organizations

B. TSK (Technological Science Knowledge)

1. Resources and Tools Available for Science Subjects

- Simulation
- Props
- Spreadsheets
- Concept maps
- MBL settings
- Multimedia
- Web app
- Source Wb Scientific
- Web 2.0 Application

2. Operational and Technical Skills Associated with Scientific Knowledge

- Use of an effective simulation to model material
- Use of an effective concept map to model material
- Use of MBL settings to support specific material experiments

3. Transformation of Scientific Knowledge

- Dynamic representations of specific scientific knowledge

- Simulations of specific scientific knowledge (macroscopic and microscopic)
- Virtual experimentation
- Experimentation using MBL
- Conceptual mapping in specific areas
- Geospatial technologies in Geography (e.g. Google Earth)
- Changes in Nature of Science

4. Transformation of scientific processes

- ICT-based problem-solving approaches in science
- New methods used to solve problems in science (e.g. using spreadsheets or modeling tools in physics)
- New methods used to analyze experimental data
- Modeling and simulation methods of specific content in physics, chemistry, biology (e.g. concepts, processes, principles)

C. TPK (Technological Pedagogical Knowledge)

1. Affordances of ICT tools

- Knowledge of the pedagogical affordances of ICT
- Knowledge and skills to identify the pedagogical properties of specific software
- Knowledge and skills to evaluate educational software
- Ability to select tools supporting specific learning approaches

2. Learning strategies supported by ICT

- Supporting experimental-practical work
- Use of constructivist approaches
- Promoting student motivation
- Fostering collaborative learning

3. Fostering scientific inquiry with ICT

- Use of scientific inquiry
- Use of scientific explanation
- Learning how to learn (autonomous learning)

4. Information skills

- Search and access of information in digital media (e.g. Web)
- Analyze and evaluate scientific content in digital media

5. Student scaffolding

- Revealing and handling students' learning difficulties
- Supporting students in conceptual change processes
- Developing cognitive conflict situations for the students
- Supporting students to develop information skills

6. Students' technical difficulties

- Supporting students to develop technical and operational skills for specific ICT applications
- Supporting students to use software modeling in specific content
- Supporting students to develop creative thinking
- Supporting students to develop critical thinking
- Supporting students to develop open ended
- Supporting students to use local culture in specific content

IV. CONCLUSION

Redesign of Technological Pedagogical Science Knowledge (TPSK) based on existing local culture can be used by teachers as a reference in developing learning model that integrates technology, pedagogy, knowledge. TPSK in science learning should be tailored to the needs and facilities available in schools.

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