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A Systematic Review on Pedagogical Content Knowledge in Utilizing Science Learning Technology at the Indonesian Junior High School Level

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Systematic review
Technology

Abstract

Knowledge of technology, pedagogy, and content needs to be mastered by teachers comprehensively. This research is systematic review research with the type of meta-synthesis which aims to describe the implementation of Pedagogical Content Knowledge (PCK) and its integration with technology in science learning at the junior high school level based on research carried out in Indonesia. The data is sourced from publications indexed on the SINTA page ranked 1-6 in 2016-2020. Data collection used the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) method. Analysis of articles related to topics used categorization on Pedagogical Content Knowledge which includes (1) Orientation to teaching science (OTS), (2) Knowledge of instructional strategies for teaching science (KIS), (3) Knowledge of student understanding in science (KSU), (4) Knowledge of curriculum (KC), (5) Knowledge of assessment of science learning (KAS). A total of 23 scientific articles were obtained from 21 scientific journals consisting of five articles indexed at level 4, four articles at level 3, eleven articles indexed in journals ranked 2, and three articles in journals ranked 1. OTS showed dominance in the didactic aspect [N=5]. KIS was dominated by the tendency of problem-solving strategies [N=3], KSU lead to teachers' understanding of students' motivation and interest [N=4], and understanding of students' abilities [N=4]. The KC identified showed the dominance of knowledge in the horizontal curriculum [N=6]. KAS shows the direction of knowledge which is dominated by formative assessment [N=16]. Utilization of technology used in the teaching and learning process takes various forms including weblog [N=1], interactive digital [N=1], ICT [N=1], Edmodo [1], audiovisual [N=1], virtual lab [N =2], smartphone [N=2], Macromedia flash [N=3], Power point [N=3], STEM Project [7].

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Introduction

Teaching is a job or profession that must be done professionally. The learning process must be carried out consistently toward the desired educational goals. A job that has been formed is handed over to people who are not experts, then the job will be destroyed. This also applies in the field of education, if a transmitter of knowledge is not following his profession, the expected goals will not be achieved. Therefore, the professionalism of an educator is necessary. One of the ways to realize professional educators is by improving and developing the quality of Pedagogical Content Knowledge (PCK).

Pedagogical Content Knowledge (PCK) is an important skill that includes understanding the process of improving scientific literacy and the ability of educators to turn knowledge into a learning process (Anwar et al., 2014). The concept of PCK, a body of characteristic

knowledge for teaching, is an acknowledgment of the significance of transforming subject matter knowledge into subject matter knowledge for learning (Shulman, 1986). PCK describes the ability of teachers to integrate content knowledge into knowledge of curriculum, teaching, and student characteristics, which can lead teachers to structure a lesson.

Various issues related to science education have developed both in government policies, students, and the environment, as well as issues of the quality of educators. Science education problems related to the educator aspect include (1) how the teacher integrates technology with science education, (2) the nature of science and inquiry, (3) the quality of science learning, (4) the use of ICT in science learning, (5) development appropriate and effective assessment for science education, (6) science education starting from elementary school, (7) increasing educator professionalism (Fensham, 2008). An educator must be able to use technology in learning in the era of technological development. The ability of educators to use technology must develop to support knowledge and skills related to teaching content and pedagogy, known as Technological Pedagogical Content Knowledge. The acronym that is often used for this framework is TPACK because it is easier to pronounce (Chai et al., 2013). The development of TPACK requires a deep understanding of the relationship between technology and teaching content as well as pedagogic skills in implementing learning.

Several experimental studies on science learning that relate to technology have been carried out by researchers in Indonesia (Badriyah et al., 2020; Khamidah et al., 2019; Maryani et al., 2016; Qosyim & Priyongo, 2017; Rohmawati et al., 2018). Organizing data on research related to TPACK needs to be done by extracting as much information as possible from previous research obtained from research databases in the Indonesian area, as well as approaching the comprehensiveness of the data. An overall review needs to be carried out in a study to see how the development of technology-integrated science learning towards Pedagogical Content Knowledge owned by educators uses the Systematic Review method and the Meta-Synthesis technique. The Systematic Review method is a literature review that uses a systematic method to collect secondary data, conduct research studies and collect qualitative and quantitative findings. The Meta-Synthesis technique is a data integration technique to obtain new theories and concepts or a more complex and comprehensive level of understanding (Utomo, 2016).

The focus of this research study is aimed at science educators at the SMP/MTs level and the sample used in this study is the result of research that has been indexed to SINTA for the last five years. Sinta is an abbreviation of the Science and Technology Index and is a portal that contains the measurement of the performance of authors, researchers, authors, and the development of the performance of journals and science and technology institutions. Sinta has the main advantage that it can automatically index works that have been indexed in Google Scholar, Scopus, InaSTI, and IPI (Indonesia Publication Index) (Ministry of Research and Technology, 2017) (Kementerian Riset dan Teknologi, 2017). In Indonesia, there is the SINTA (Science and Technology Index) which is the official platform used to measure the quality of research and scientific publications made by Indonesian academics. In higher education in Indonesia, citation management is carried out using the SINTA score (Aini et al., 2019). SINTA is linked to various kinds of data from Indonesian academics covering intellectual property rights, namely copyrights, patents, and brands (Rizqy, 2019). SINTA is also linked to book data available at the National Library and with the Google Scholar

database, so it is not uncommon for various workshops to be held related to the use of SINTA and Google Scholar (Fadhilaturrahmi et al., 2020).

Method

This study used the method of Systematic Review and Meta-synthesis to obtain articles that meet the criteria (Wright et al., 2007), the steps include:

1. ***Background and purpose***

   At this stage, the background and research objectives are specifically formulated, namely to analyze the application and mastery of educators in Pedagogical Content Knowledge.

2. ***Research Question***

   Research questions or research questions are formulated based on the needs of the chosen topic (Wahono, 2015). The questions in this study consist of:

   RQ1: What is the technology model that is often applied to junior high school science learning?

   RQ2: What are the PCK components that have been implemented by educators in science learning?

   RQ3: What are the topics of science lessons that use technology in junior high school learning?

3. ***Search Process***

   The stages of the search process aim to obtain relevant sources to answer the Research question (RQ) and other related references. The search process was carried out using a journal database developed by the Republic of Indonesia, namely SINTA https://sinta.ristekbrin.go.id/

4. ***Inclusion and Exclusion Criteria***

   This stage is carried out to decide whether the data found are suitable for use or not. A study is eligible to be selected if the following criteria are met:

   a) Data used in the period 2016-2020

   b) Data obtained through the site https://sinta.ristekbrin.go.id/

   c) The data used only relates to the implementation of science learning for junior high school level utilizing technology.

   d) The research was conducted in Indonesia.

   At this stage, The framework for determining criteria and exceptions is shown in Figure 1.

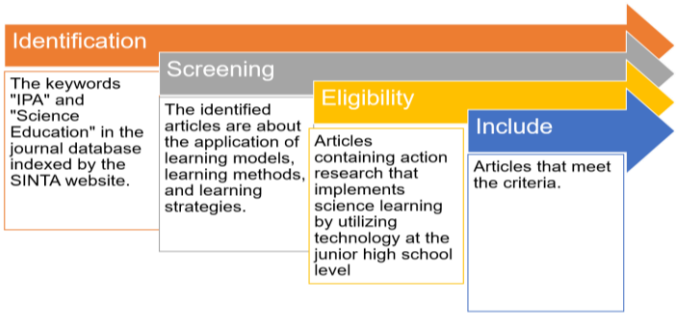


Figure 1. The Framework of the Article Selection Process in A Systematic Review.

Journal identity analysis is adjusted according to the criteria to avoid duplicate data. The results are presented in the form of a table containing the title, type of journal, name of the researcher, rank of the journal on the SINTA page, year of publication, research participants, grade level used in the study, and research location.

5. ***Quality Assessment***

The data from the selection results will be evaluated based on the following quality assessment criteria questions:

QA.1 Was the article published in 2016–2020?

QA.2 Does the article list the research location in junior high school?

QA.3 Does the article write about learning that uses technology?

QA.4 Does the article write about specific lesson topics in implementing science learning?

6. ***Data Collection***.

This step is carried out by searching for articles by analyzing one by one the journal pages of each publishing edition starting from 2016-2020. The scientific articles collected are articles that examine science learning that utilizes technology. Furthermore, the findings are classified based on the level of education from elementary school, junior high school, and high school. Adjustment to the inclusion criteria was carried out by identifying one by one article by reading the entire contents and noting the important parts according to the criteria rubric.

A systematic review is a research method used to identify, evaluate, and interpret all of the results of research related to certain questions, topics, and phenomena of interest. The systematic review consists of two techniques to result from literature findings to present comprehensive facts. These techniques are quantitative (meta-analysis) and qualitative (meta-synthesis) techniques. In this research, a qualitative (meta-synthesis) technique was used. Meta-synthesis is a technique for summarizing the result of research to acquire new theories, concepts, or understanding on a deeper level (Wahono, 2015).

The data was then analyzed using Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) which was performed systematically by the proper research steps through the presentation of the facts followed by analysis (meta-synthesis). The steps of systematic review are highly planned and systematic, the consequence of which, research using this method differs from one that only presents literary studies. The implementation of systematic review research consists of several stages, namely (1) identifying research questions, (2) developing research protocol, (3) determining the database location of the search area, (4) selecting relevant research results, (5) selecting criteria, (6) extracting data, (7) synthesizing results using meta-synthesis, and (8) presenting the results. A detailed explanation is presented in Table 1.

Table 1. Stages In The Analysis Using PRISMA

No	Stages	Description
1	Identifying research questions	Researchers identify research questions to be used as a reference in searching for article data to avoid unqualified article sources.
2	Developing research protocols	Researcher find published studies related to learning processes that implement technology.
3	Determining the location of the search area database	Researchers set limits in the search for scientific articles by using predetermined keywords.
4	Selecting relevant research results	The data is accessed according to the topics that have been determined in this research process and selected based on the criteria that have been determined by the researcher.
5	Selection criteria	Researchers select scientific articles from the search results and group them for further sorting in the next stage.
6	Data extraction	Research journals that match the inclusion criteria were collected and summarized in the form of a table containing the research title, name of the researcher, and location. The table is to further clarifies the researcher in analyzing the data further.
7	Synthesizing results using meta-synthesis	Researchers group important data that will be studied in depth regarding the content, facts, and information contained in the research article which will be concluded to answer research questions.
8	Presenting results	The data that has been analyzed is then presented in tabular form including the title of the study, the name of the researcher, the subject at the junior high school, the grade level, and the technology used.

The main source of this research is various literature regarding classes that implement technology at the Junior High School level found in scientific journals indexed on SINTA indexing pages ranked 1-6. The data source was searched on each edition published by scientific journals in the last four years (2016-2020). Data was collected through documentation by collecting documents on the SINTA pages that met the criteria of the research subject. Researchers then used the process framework shown in Figure 2 to insert the article for further discussion.

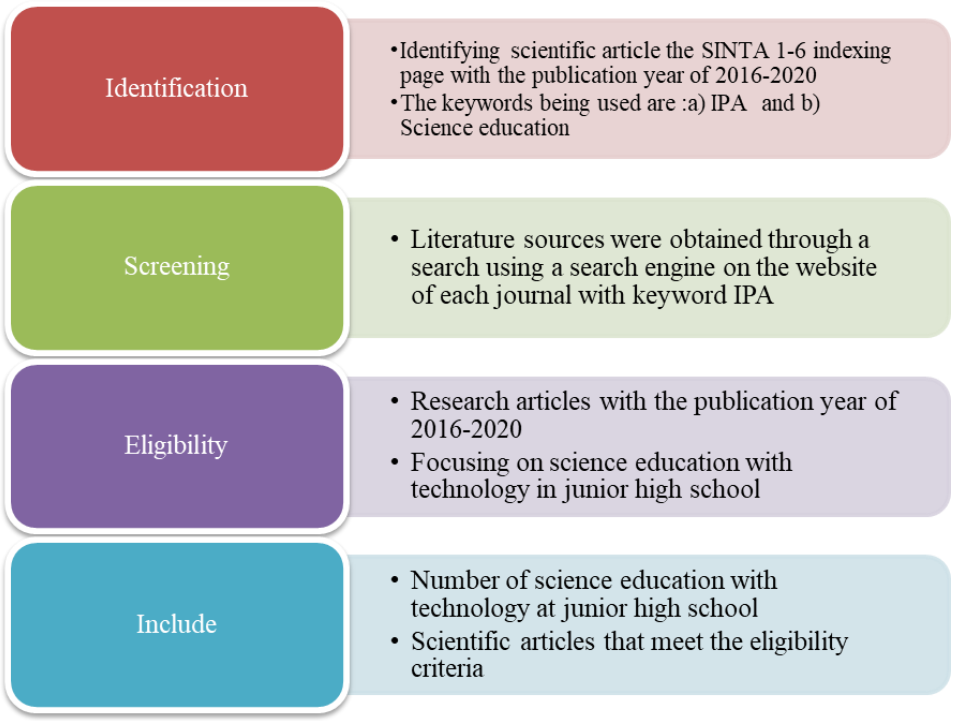


Figure 2. Process Framework in the Determination of Scientific Articles

Results and Discussion

At the initial stage of the research, researchers determined the SINTA indexing pages 1-6 with the publication year of 2016-2020 as the database to find literature published in several scientific journals. Furthermore, the data collection process began by reading the abstracts of each piece of literature to determine its relevance to the topic of the current research. The initial finding is shown in Figure 3.

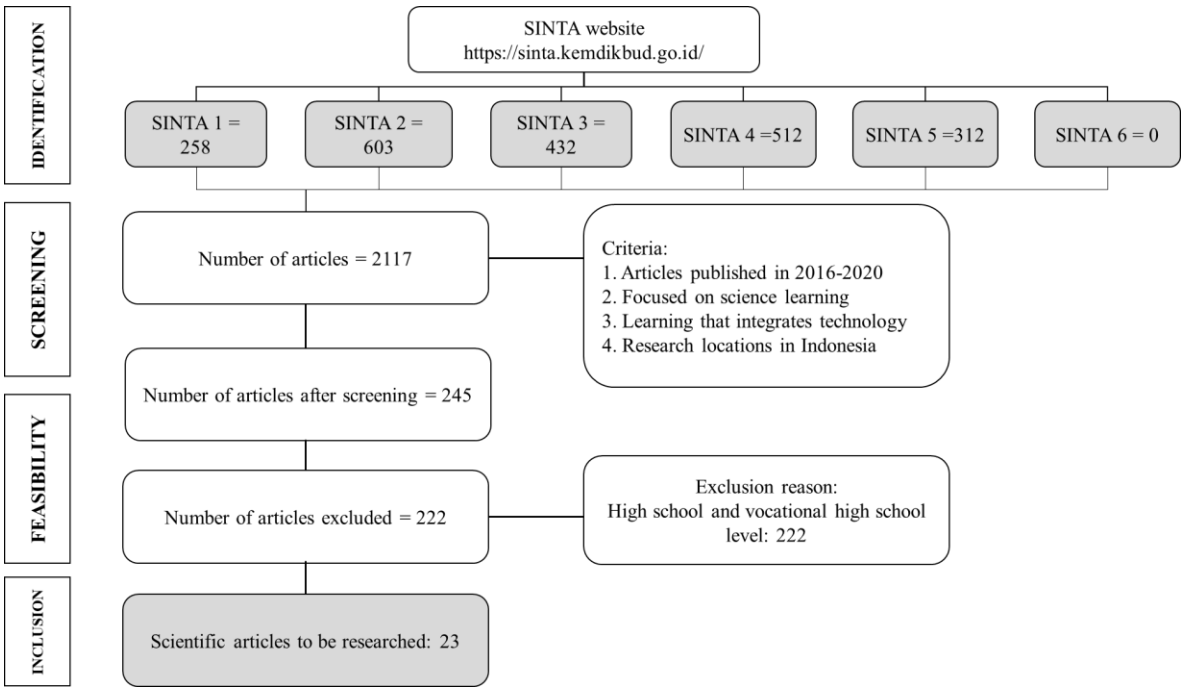
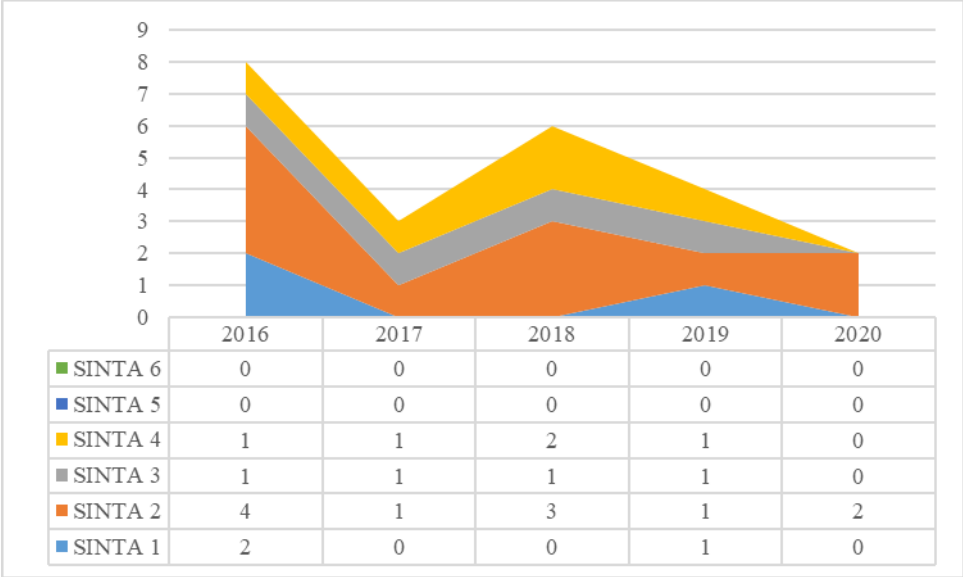


Figure 3. Initial Findings Using PRISMA Diagram

Researchers screened the articles by reading their abstracts. The main point of this stage is to acquire research studies relevant to the topic of the implementation of PCK in the learning process by implementing technology. Pedagogical content knowledge is the ability of a teacher to master the content (subject matter) and pedagogical knowledge. Content is the knowledge that must be mastered by educators, consisting of facts, concepts, laws and theories, principles, mastery of materials, scientific paradigms that bolster the subject, and consistent development of behavior. Meanwhile, pedagogy is the method that can be used to help students learn and solve learning problems (Zuhaida, 2018). Based on 2117 reviewed articles, researchers found 23 relevant ones, the distribution of which is shown in Figure 4.



	2016	2017	2018	2019	2020
SINTA 6	0	0	0	0	0
SINTA 5	0	0	0	0	0
SINTA 4	1	1	2	1	0
SINTA 3	1	1	1	1	0
SINTA 2	4	1	3	1	2
SINTA 1	2	0	0	1	0

Figure 4. The Development of Research Related to PCK and Technology (2016 – 2020).

The selection resulted in 23 articles which were further analyzed based on their titles, types of journals, SINTA rankings of the journals, years of publication, author names, research location, and class level in formal school. Tabulated details of the articles are shown in Table 2. The articles are given codes to classify them based on their journal rankings. The codification is done by adding alphabets, the letter A being given to the articles published in journals ranked 1 (S1), B to ones published in journals ranked 2 (S2), C to ones published in journals ranked 3 (S3), D to ones published in journals ranked 4 (S4), E to ones published in journals ranked 5 (S5), and F to ones published in journals ranked 6 (S6). A detailed explanation is shown in Table 2.

Table 2. Scientific Journals that match the criteria for the inclusion stage in the PRISMA

Code	Title (Researcher and Publication Year)	Publisher	Research Location	Grade
A1	The Effectiveness of Android Application as A Student Aid Tool In Understanding Physics Project Assignments (Safitri et al., 2019)	Jurnal Pendidikan IPA Indonesia	SMP Islam Terpadu Arrozaq Rantauprapat, Sumatra Utara	VIII
A2	Project-Based Learning Integrated to STEM Enhance Elementary School's Scientific Literacy (Afriana et al., 2016b)	Jurnal Pendidikan IPA Indonesia	SMP Islam Terpadu Sukabumi, Jawa Timur	VII
A3	STEM Learning In Material of Temperature and Its Change to Improve Scientific Literacy of Junior High School Students (Khaeroningtyas et al., 2016)	Jurnal Pendidikan IPA Indonesia	SMPN 1 Bumiayu, Jawa Tengah	VII
B1	Application of PjBL with Brain-based STEAM Approach to Improve Learning Achievement (Badriyah et al., 2020)	Jurnal Inovasi Pendidikan IPA	SMP Plus Miftahul Ulum, Jawa Timur	VIII
B2	*Efektifitas Virtual Lab Berbasis STEM dalam Meningkatkan Literasi Sains Siswa dengan Perbedaan Gender* [The Effectiveness of STEM-Based Virtual Labs in Improving Science Literacy of Students with Gender Differences] (Ismail et al., 2016)	Jurnal Inovasi Pendidikan IPA	SMP IT Adzkia, Sumatra Barat	VII
B3	*Penerapan Project Based Learning Terintegrasi STEM untuk Meningkatkan Literasi Sains Siswa Ditinjau dari Gende* [Application of STEM Integrated Project Based Learning to Improve Students' Science Literacy in terms of Gender] (Afriana et al., 2016a)	Jurnal Inovasi Pendidikan IPA	SMP Islam Terpadu Sukabumi, Jawa Barat	VII
B4	*Penerapan Blended Learning dengan Aplikasi Edmodo Berbasis Strategi Pembelajaran PDEODE untuk Meningkatkan Prestasi Belajar Siswa* [The Implementation of Blended Learning using Edmodo Application Based on PDEODE Learning Strategy to Increase Students' Learning Achievement] (Ekawati, 2018)	Jurnal Ilmiah Pendidikan MIPA	MTsN Magelang, Jawa Tengah	VIII
B5	*Pemanfaatan Audio Visual Berbasis Discovery Learning Terhadap Peningkatan Keterampilan Berfikir Kritis pada Materi Sistem organ dan Organisme* [The use of Audio Visual Based Discovery Learning towards the Imrovement of Critical Thinking Skill in the Topic of Organ and Organism System] (Rizal et al., 2017)	Jurnal Pendidikan Sains Indonesia	MTsN Tungkop Aceh Besar, Aceh	VII
B6	*Implementasi Pembelajaran STEM pada Materi Sistem Reproduksi Tumbuhan dan Hewan Terhadasp Kemampuan Berfikir Ilmiah Peserta Didik SMP*/The implementation of STEM Learning in the Topic of Reproductive System of Plants	Jurnal penelitian pendidikan IPA	SMP Negeri 1 Sigli dan SMP Negeri 2 Peukan Pidie, Aceh	IX

Code	Title (Researcher and Publication Year)	Publisher	Research Location	Grade
	and Animals towards Junior High School Students' Scientific Thinking Skill (Agustina et al., 2020)			
B7	Using Macro Flash Animation Media on Motion Material to Improve Learning Achievement for Learning Science in Junior High School(Saripudin et al., 2018)	Jurnal Penelitian dan Pembelajaran IPA	SMPN 1 Mancak, Banten	VIII
B8	The Influence of Learning by Smartphones to the Conceptual Science Knowledge and the Independence of Students' Learning at Junior High School(Hasanah et al., 2018)	Jurnal Penelitian dan Pembelajaran IPA	SMP Kota Serang, Banten	VII
B9	*Pemanfatan Pembelajaran Berbasis Komputer Model CD Interaktif Tutorial Untuk Meningkatkan Hasil Belajar* [The use of Computer Based CD Interactive Tutorial Model to Improve Learning Outcome] (Sutarman, 2016)	Jurnal Penelitian dan Pembelajaran IPA	SMPN Kabupaten Serang, Banten	VII
B10	*Pengaruh Pendekatan Contextual Teaching and Learning (CTL) Berbantuan Media Powerpoint terhadap Peningkatan Hasil Belajar IPA fisika* [The effect of Contextual Teaching and Learning (CTL) Approach Assisted by Powerpoint Medium towards Physics Learning Outcome Improvement] (Suprianto et al., 2016)	Jurnal Penelitian dan Pembelajaran IPA	MTs Mambaul Ulum Sampang, Jawa Timur	VIII
B11	The Implementation of PBL Integrated with STEM in the Material of Temperature and Its Changes to the Improvement of Students' Creative Thinking Skills and Learning Results (Madyani et al., 2019)	Journal of Educational Science and Technology	SMP Surakarta, Jawa Tengah	VII
C1	*Peningkatan Pemahaman Konsep dan Motivasi Belajar Siswa Melalui Simulasi Physic Education Technologiy (PhET)* [Improving Students' Conceptual Understanding and Learning Motivation using Physic Education Technology (PhET) Simulation] (Khairunnisak, 2018)	Jurnal penelitian pendidikan IPA	MTs Insan Qur'ani Aceh Besar, Aceh	VIII
C2	*Implementasi Model Pembeljaran Advance Organizer Menggunakan Animasi Ditinjau dari minat Belajar terhadap Hasil Belajar Kognitif Siswa Kelas VII pada pelajaran IPA di SMPN 1 Batukliang Tahun Ajaran 2014/2015* [The Implementation of Advance Organizer Learning Model Using Animation from the Perspective of Students' Learning Motivation towards Coginitive Learning Outcome of 7th Grade Student in the Subject of Science in SMPN 1 Batukliang in the School Year 2014/2015] (Maryani et al., 2016)	Jurnal penelitian pendidikan IPA	SMPN 1 Batukliang, Nusa Tenggara Barat	VII
C3	*Discovey Learning : Penerapan dalam pembelajaran IPA berbantuan bahan ajar*	Jurnal Pendidikan IPA Veteran	MTsN 3 Ponorogo, Jawa	VIII

Code	Title (Researcher and Publication Year)	Publisher	Research Location	Grade
	digital Interaktif untuk meningkatkan prestasi belajar siswa [Discovery Learning: The Implementation of IPA Learning Assisted by Digital Interactive Learning Medium to Improve Students' Learning Achievemnt] (Khamidah et al., 2019)		Timur	
C4	*Pemanfatan Media Pembelajaran ICT Sebagai Kegiatan Pembelajaran Siswa di SMP Negeri Aceh Tamiang* [The use of ICT Learning Media in Students' Learning Activity in SMP Negeri Aceh Tamiang] (Nursamsu & Kusnafizal, 2017)	Jurnal IPA dan Pembelajaran IPA	SMPN Aceh Tamiang, Aceh	VIII
D1	*Penerapan Media Pembelajaran Interaktif Menggunkan FLASH Untuk Materi Sistem Gerak pada Manusia Kelas VIII* [The use of Interactive Learning Media Using Flash in the Material of Motor System in Humans Class VIII] (Qosyim & Priyongo, 2017)	Jurnal Penelitian Pendidikan IPA	SMPN 3 Sidoharjo, Jawa Timur	VIII
D2	*Peningkatan Kemampuan Mendeskripsikan Proses Pembentukan Bayangan Melalui Media Animasi pada Siswa Kelas VIII-G SMPN 1 Puncu* [Improving Students' Ability to Discribe Image Formation Process by Using Flash Animated Media in Grade 7-G Students at SMPN 1 Puncu] (Nugraheni, 2018)	Jurnal Penelitian Pendidikan IPA	SMP Negeri 1 Puncu Kab Kediri, Jawa Timur	VIII
D3	*Membangun Kemampuan Literasi Sains Siswa Melalui Pembelajaran Berkonteks Sosio-Scientific Issues Berbantuan Media WEBLOG* [Building Students' Scientific Literacy Through Socio-Scientific Issues Contextual Learning Assisted by WEBLOG] Media(Rohmawati et al., 2018)	Jurnal Penelitian Pendidikan IPA	SMP Negeri 1 Sukodadi, Jawa Timur	VIII
D4	Increasing Creative Thinking Skills and Understanding of Physics Concepts Through Applications Of STEM- based Inquiry (Dewi et al., 2019)	Jurnal Penelitian Pendidikan IPA	Mts Sunan Ampel Nganjuk, Jawa Timur	VII
D5	*Upaya Meningkatkan Kreativitas Belajar Ilmu Pengetahuan Alam (IPA) Siswa Melalui Penerapan Model Pembelajaran Kooperatif Tipe THINK-PAIR-SHARE(TPS) Berbantuan Media Komputer*/Improving Students' Creativity in Learning Science by Implementing Cooperative Learning Think-Pair-Share (TPS) Model Assisted by Computer (Harahap, 2016)	ESAKTA "Jurnal Penelitian dan Pembelajaran MIPA"	SMP Negeri 8 Padang sidimpuan, Sumatra Barat	VIII

The modern world is marked by the digital revolution and technological disruption era also known as Industry 4.0 (Ghufron, 2018). The development of the era must also be accompanied by a development in education. As Industry 4.0 is marked with technology, education has to keep up by integrating learning with technology. Based on the researchers'

data collection, several articles were found related to the integration of learning with technology.

Overall, after the search process, 21 types of journals were found. After the data were selected based on inclusion and exclusion criteria, 245 journal articles were then given quality assessment. 23 relevant articles were grouped based on their elaboration and approach to be used to answer the research question. The result, which answers RQ 1 and is presented in Figure 5, shows that the learning process predominantly used in science learning process is STEM Project

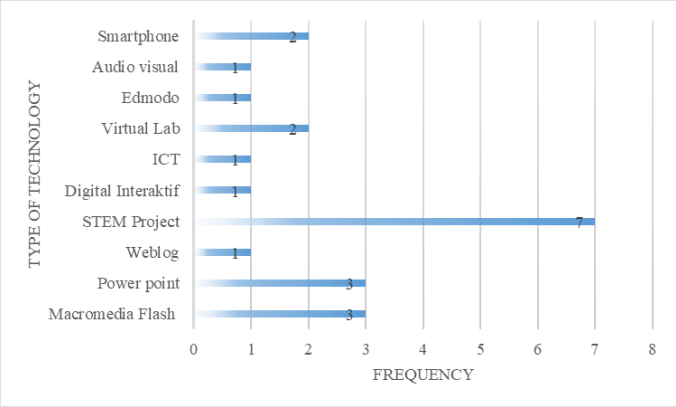


Figure 5. Technology Utilization for Teaching Science

Science, Technology, Engineering, and Mathematics (STEM) education-based learning process is an approach to prepare students in applying their knowledge to solve complex problems and develop their STEM competence (Haryanti & Suwarma, 2018). The result of the research (A2, A3, B1, B3, B6, B11, D4) showed that the articles implementing STEM project-based learning can increase scientific literacy, critical thinking skills, and scientific concept comprehension.

The educator plays a key role in the success of education. An educator must maintain his professionalism as an educator, whose skill includes pedagogical content knowledge. The type of pedagogical content knowledge discussed by the researcher is pentagonal, with the categories of OTS (Orientation to Teaching Science), KISR (Knowledge of Instructional Strategies for Teaching Science), KSU (Knowledge of Student Understanding in Science), KSC (Knowledge of Science Curriculum), and KAs (Knowledge of Assessment of Science Learning) (Imaduddin et al., 2014). The result found the 23 articles shown in Figure 5.

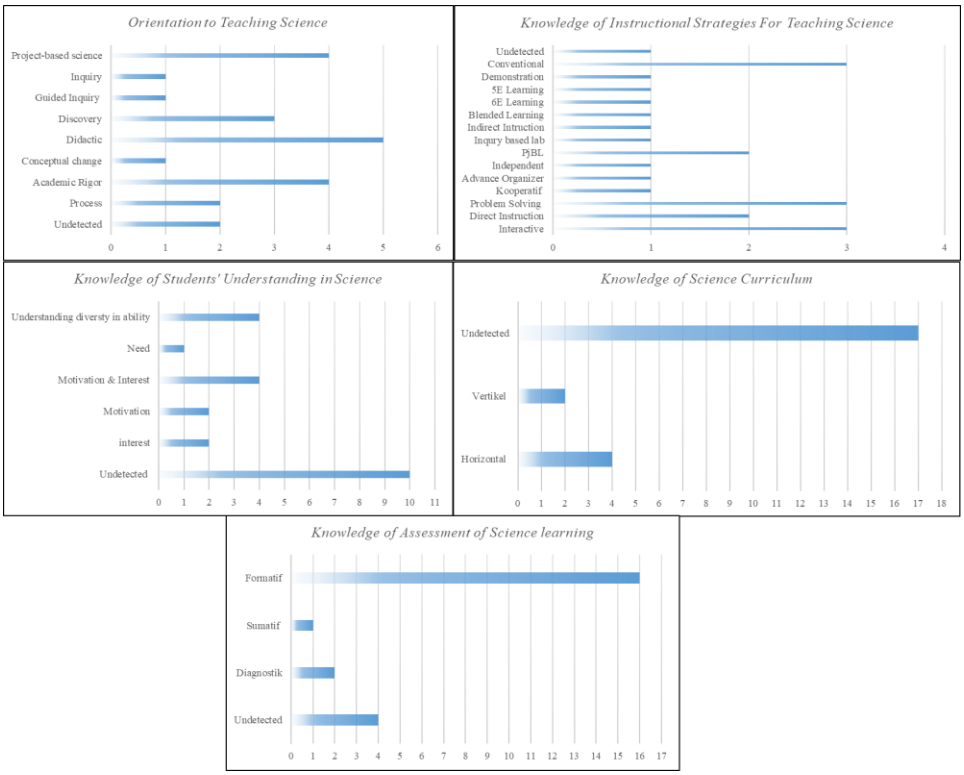


Figure 6. *Classification of PCK Component Types Based on Scientific Article Findings*

The 23 articles showed various teachers' orientations in teaching science. The educators' orientations in teaching science are shown in Table 3.

Table 3. Analysis of Orientation in Teaching Science

Orientation to teaching science (OTS)	
Category	**Code**
Didactic	C1 B4 B7 B9 A3
Academic rigor	D3 C2 B10 B 11
Project-based science	A1 A2 B1 B3
Discovery	C3 B5 B6
Process	D1,C4
Guided inquiry	D4
Conceptual change	D5

The educators' knowledge of teaching strategy in this research informed that the use of strategy or learning method must be adapted to the science material being taught. The study found varied results regarding learning strategy. A detailed explanation is shown in Table 4.

Table 4. Analysis of Knowledge of Instructional Strategies for Teaching Science (KISR)

Knowledge of instructional strategies for teaching science (KISR)	
Category	**Code**
Direct instruction	A1 D2
Problem-solving	D3 D4 B11
Cooperative	D5
Conventional	C1 B9 B10
Advance organizer	C2
Interactive	D1 B3
Independent	C4
PjBL	B1 A2
Inquiry-based lab	B2
Blended learning	B4
5E learning	B6
Demonstration	B7
6E learning	A3

The analysis of teachers' knowledge of student understanding of science showed varied results. There are five categories of KSU, namely motivation, interest, motivation, and interest, understanding of ability, and need. The result of the research derived from journals is shown in detail in Table 5.

Table 5. Analysis of Knowledge of Student Understanding in Science (KSU)

***Knowledge of student understanding in science* (KSU)**	
Category	**Code**
Motivation	C1 C4
Interest	C2 B5
Motivation and interest	A2 B3 C3 D5
Understanding of ability	B2 B6 B7 D3
Need	D3

Assessment or evaluation in the learning process is aimed to determine whether or not the result of a learning process is aligned with the expected result. Knowledge of assessment consists of 3 categories of assessments, including formative (pretest and post-test), diagnostic (checklist), and summative test. The result is elaborated in Table 6.

Table 6. Analysis of Knowledge of Assessment of Science Learning (KAs)

***Knowledge of assessment of science learning* (KAs)**	
Category	**Code**
Formative	D1 D2 D3 D4 C2 C3 C4 B2 B4 B5 B6 B9 B10 B11 A2 A3
Summative	D5
Diagnostic	B3 A1

The curriculum is an instrument of the learning process comprised of the design of the lessons to be given to students in a period of an educational level. The knowledge of the curriculum in the current study consists of 2 types of curriculums; horizontal and vertical. A horizontal curriculum is the organization of the learning materials given to students, while a vertical curriculum consists of classroom system usage, time allocation to each subject, and

subject matter in the implementation of the learning process. The result of the study shows that the knowledge of horizontal and vertical curricula is as shown in Table 7.

Table 7. Analysis of Knowledge of Science Curriculum (KSC)

Knowledge of Science Curriculum (KSC)	
Category	**Code**
Horizontal	B2 B4 C4 D1 D2 D3
Vertical	C3

Teacher plays a key role in science learning. Teachers must be able to develop students' interest in science by relating it to their daily life so that the goal of increasing students' interest in science is achieved (Sari, 2013). Therefore, a teacher with high quality is needed. Teachers' professionalism needs to be increased so that students are interested in the lesson. The way teachers teach is usually called teaching strategy. Because of its considerable influence on students' interests, pedagogic knowledge is important for teachers to have. The research on articles related to science lessons using pentagonal PCK had varying results.

Nowadays pedagogic knowledge is supported by the implementation of technology in the learning process. The use of technology in the classroom by teachers is almost mandatory because the development of today's technology can provide solutions to improve the quality of education in Indonesia which is already left behind by those of developed nations. The implementation of technology in education can be done through learning media. Students' learning outcome is closely related to the learning process performed. Successful learning processes can often be seen as the result of learning processes supported by adequate learning facilities.

Besides the learning facility, teachers' implementation of the method can allow students to enjoy the learning process. One of the unique methods that can be implemented is by using computer or audio-visual as learning media. Utilization of technology in the learning process can be in the form of using the internet during the learning process (e-learning) or by using the computer as an interactive media.

Several articles discuss science classrooms that integrated technology into the SINTA database. Based on the analysis of the articles, it was found that the use of technology in science classrooms in certain topics at the junior high school level produced varied results for the students. On the topic of the life organization system, the research by Kairul Rizal (2017) utilized a learning model based on discovery learning, which integrated audio-visual aid into the learning process. It was shown that the learning model gather students' interest in the learning process. This is similar to the research done by Marti (2014) regarding the use of audiovisual aid in the topic of life organization systems which can increase students' learning outcomes (Marti et al., 2014). Audio-visual media are media that can present moving pictures, and colors, accompanied with explanation in the form of writing and sound.

With the ecosystem as the topic, the research done by Adang Sutarman (2016) studied a learning model utilizing PowerPoint tutorial CD. The result of this research, which utilized a tutorial model, is considered effective in increasing students' learning outcomes. A more appropriate approach to use to convey this material is the local environment exploration

approach, which utilizes the environment around the students, whether it's physical, social, technological, or cultural environment as the object of which phenomena are studied through scientific work (Sari et al., 2013). The JAS (*Jelajah Alam Sekitar*/ Explore the Surroundings) approach to learning utilizes the environment combined with science and technology. This is in line with the study by Ahmad Hakim (2019), a learning process utilizing the JAS approach taking advantage of the YouTube application can be accessed anytime (Raja, 2019).

The topic of environmental pollution using the STEM project approach was studied by Afrina (2016), Ismail (2016), and Jaka Afrina (2016). STEM-based learning implemented resulted in a positive response from the students in addition to increasing students' literacy. The incident of environmental pollution is an issue close to people's daily life. To solve such issue, critical thinking skill is needed. This is supported by the study by Sastri Novayani (2015) which showed that the learning process utilizing the discovery learning model can affect students' critical thinking ability (Novayani, 2015). The topic of environmental pollution can also be taught using the learning 7E model because students are trained to find knowledge from what they are going to study themselves and to play an active role (Ratnasari, 2018).

The topic of temperature and heat can be taught using various models as presented by the study by N. Khaeroningtyas, and A. Permanasari, (2016) by using the STEM approach. This learning process was able to improve students' scientific literacy. Research by Ida Madyani (2019) used a STEM approach based on a problem-solving model was able to improve student's critical thinking skills. The problem-based learning model is widely used in the topic of temperature and heat because the activities are closely related to daily life, such as boiling water or heating an iron. This is supported by the research of Ahmad Farisi (2017) which utilized a problem-based learning model, whose result was able to develop students' critical thinking skills (Farisi et al., 2017). On the other hand, research by Ibnu Hasanah (2018) utilized smartphones as learning media as it was considered effective for Junior High School, allowing students to play a more active role to find information instead of being bound by books.

In the research by Endang Saripudin (2018) and Ahmad Qosim (2017), the lesson on this topic used flash media as the medium. The use of flash media was considered practical and effective to be used as learning media. The use of flash media was able to increase students' enjoyment in the learning process related to the human motoric system. All of the components in this topic are interconnected to each other. If one of the components does not function, it will interfere with the others. Some bones need to be understood to avoid injury. Therefore, school lessons related to this topic have to get students interested so that the lesson can be conveyed clearly.

The topic of light and optics contains both declarative and procedural knowledge. The subtopic of light reflection and refraction, for instance, contains declarative knowledge in the form of explaining light reflection and refraction law through experiments. On the other hand, an example of procedural knowledge would be the subtopic of determining the image magnification in a mirror and lens (Yahyana et al., 2017). The study by Ngulmi Khamidah (2019) concluded that the learning process utilizing digital interactive media was able to increase students' learning outcomes. Meanwhile, the study by Widyanti Nugraheni (2018) in which the learning process used PowerPoint animation as a medium was able to increase

VIII- G SMPN 1 Puncu students' ability to describe the process of image formation in the event of reflection and refraction.

On the topic of sound, the learning process studied by Nur Lailatul Badriyah (2020) used a STEM process that was able to increase students' achievement in addition to their skill in performing scientific experiments. In the topic of fluid pressure, the learning process studied by Kharunnisak (2018) utilized a PhET medium. The use of the PhET medium helped to make it easier for both teachers and students in the practice-based learning process. PhET is a virtual lab software that simulates interactive physics. It is available to download for free from the website and can be run online or offline. The software can be used by students to do simulated practice before performing real experiments so that they can master the concepts of the experiment (Dina, 2019).

The analysis performed on 23 articles regarding teachers' use of technology in the learning process brought in varied results. Technological Pedagogical Content Knowledge (TPCK) is the knowledge needed by educators to integrate technology into the learning process of certain material into a complete package. Teachers must possess an intuitive understanding of the complex interaction between 3 basic components of knowledge; PK, CK, and TK by conveying certain materials using the appropriate pedagogic method and technology. Its connection to technology, according to studies that support the establishment of TPCK, is the presence of PCK, TCK, and TPK. Technological Content Knowledge (TCK) is knowledge of the reciprocal relationship between technology and content. This knowledge encourages teachers to understand that the use of certain technology would change the way the concept of certain content is understood.

We can conclude that educators' TCK were using technology to help students understand science theoretical concepts and were aware of various applications related to technology. PowerPoint, flash, weblog, virtual lab, STEM approach, audiovisual media, smartphone, Edmode, ICT, and digital interactive media are useful technologies that can be used in the learning process. With these applications, it is hoped that students would be able to understand materials that are difficult to explain without the help of those media.

Conclusion

Based on the result of the research found on the SINTA page ranked 1 to 6 published between 2016–2020 focusing on the research on the use of technology in the science learning process. In the science learning process at SMP/MTs (junior high school) level, educators have the pedagogical content knowledge. Consequently, this has increased students' learning outcomes, critical thinking skills, as well as literacy. The utilization of technology in the learning process had taken various forms, namely Flash, PowerPoint, weblog, ICT, Edmodo, audiovisual media, STEM Projects, and smartphones.

This research is still very limited to reviewing various scientific articles indexed on the SINTA page. The use of other indexing pages, such as Scopus, WoS, or ERIC needs to be considered in further research to obtain various references to educators' PCK conditions in science learning. The results obtained reveal roughly how the presentation of science learning has been implemented by educators and researchers on classroom action topics, so that this can be followed up with research related to TPACK to science educators with a more comprehensive perspective.

References

Afriana, J., Permanasari, A., & Fitriani, A. (2016a). Penerapan project based learning terintegrasi STEM untuk meningkatkan literasi sains siswa ditinjau dari gender [Implementation of STEM-integrated project-based learning to increase students' scientific literacy in terms of gender]. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 202–212. https://doi.org/10.21831/jipi.v2i2.8561

Afriana, J., Permanasari, A., & Fitriani, A. (2016b). Project based learning integrated to stem to enhance elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493

Agustina, R., Huda, I., & Nurmaliah, C. (2020). Implementasi pembelajaran STEM pada materi sistem reproduksi tumbuhan dan hewan terhadap kemampuan berfikir ilmiah peserta didik SMP [Implementation of STEM learning on plant and animal reproductive system material on the scientific thinking abilities of . *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *8*, 241–256. https://doi.org/10.24815/jpsi.v8i2.16913

Aini, Q., Handayani, I., & Dewi, S. R. (2019). Manajemen sitasi dan publikasi ilmiah menggunakan SINTA score dalam meningkatkan reputasi peneliti [Citation management and scientific publication using SINTA score in improving researcher's reputation]. *Informatika Mulawarman: Jurnal Ilmiah Ilmu Komputer*, *14*(2), 94–102. https://doi.org/10.30872/jim.v14i2.1815

Anwar, Y., Rustaman, N. Y., & Widodo, A. (2014). Hypothetical model to developing pedagogical content knowledge (PCK) prospective biology teachers in consecutive approach. *International Journal of Science and Research (IJSR)*, *3*(12), 138–143. https://www.ijsr.net/archive/v3i12/U1VCMTQyNTU=.pdf

Badriyah, N. L., Anekawati, A., & Azizah, L. F. (2020). Application of PjBL with brain-based STEAM approach to improve learning achievement of students. *Jurnal Inovasi Pendidikan IPA*, *6*(1), 88–100. https://doi.org/10.21831/jipi.v6i1.29884

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology and Society*, *16*(2), 31–51. https://www.researchgate.net/publication/290044779_A_Review_of_Technological_Pedagogical_Content_Knowledge

Dewi, H. R., Mayasari, T., & Handhika, J. (2019). Increasing creative thinking skills and understanding of physics concepts through application of STEM-based inquiry. *Jurnal Penelitian Pendidikan IPA*, *4*(1), 25–30. https://doi.org/10.26740/jppipa.v4n1.p25-30

Ekawati, N. E. (2018). Application of blended learning with Edmodo application based on PDEODE learning strategy to increase student learning achievement. *Jurnal Ilmiah Pendidikan MIPA*, *8*(1), 7–16. https://doi.org/10.30998/formatif.v8i1.2303

Fadhilaturrahmi, F., Erlinawati, E., & Ananda, R. (2020). Workshop sinta 2 dan google schoolar di Universitas Pahlawan Tuanku Tambusai [Workshop of sinta 2 and google schoolar at Universitas Pahlawan Tuanku Tambusai]. *Jurnal Abdidas*, *1*(4), 203–2019. https://doi.org/10.31004/abdidas.v1i4.45

Fensham, J. P. (2008). *Science education policy-making: Eleven emerging issues*. UNESCO, Section for Science, Technical and Vocational Education. https://doi.org/10.1007/0-306-47653-3_2

Harahap, A. F. D. (2016). Upaya meningkatkan kreativitas belajar ilmu pengetahuan alam (IPA) siswa melalui penerapan model pembelajaran kooperatif tipe think-pair-share (TPS) berbantuan media komputer [Efforts to increase students' creativity on natural science learning through th. *Jurnal Eksakta: Jurnal Penelitian Dan Pembelajaran MIPA*, *2*, 28–33. https://doi.org/10.31604/eksakta.v1i2.%25p

Hasanah, I., Hasani, A., Fatah, A., Sari, I. J., & Romdani, A. (2018). The influence of learning by smartphone to the conceptual science knowledge and the independence of students' learning at junior high school. *Jurnal Penelitian Dan Pembelajaran IPA*, *4*(2), 158–166. https://doi.org/10.30870/jppi.v4i2.3925

Imaduddin, M., Hidayah, F. F., & Astuti, A. P. (2014). Deskripsi pedagogical content knowledge guru kimia menggunakan komponen model pentagon [Description of the chemistry teacher's pedagogical content knowledge using the pentagon model component]. *Jurnal Pendidikan Sains*, *02*(01), 26–35. https://doi.org/10.26714/jps.2.1.2014.26-35

Ismail, I., Permanasari, A., & Setiawan, W. (2016). Efektivitas virtual lab berbasis STEM dalam meningkatkan literasi sains siswa dengan perbedaan gender [The effectiveness of STEM-based virtual labs in increasing scientific literacy of students with gender differences]. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 190–201. https://doi.org/10.21831/jipi.v2i2.8570

Kementerian Riset dan Teknologi. (2017). *Science and Technology Index*. https://sinta.kemdikbud.go.id/

Khaeroningtyas, N., Permanasari, A., & Hamidah, I. (2016). STEM learning in material of temperature and its change to improve scientific literacy of junior high school students. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 94–100. https://doi.org/10.15294/jpii.v5i1.5797

Khairunnisak, K. (2018). Peningkatan pemahaman konsep dan motivasi belajar siswa melalui simulasi physic education technology (PhET) [Increasing students' understanding of concepts and learning motivation through physics education technology (PhET) simulations]. *Jurnal Penelitian Pendidikan IPA*. https://doi.org/10.29303/jppipa.v4i2.109

Khamidah, N., Winarto, W., & Mustikasari, V. R. (2019). Discovery learning : Penerapan dalam pembelajaran IPA berbantuan bahan ajar digital interaktif untuk meningkatkan prestasi belajar siswa [Discovery learning: Application in science learning assisted by interactive digital teaching materials to improve stu. *Jurnal Pendidikan IPA Veteran*, *3*, 87–99. https://doi.org/10.31331/jipva.v3i1.770

Madyani, I., Yamtinah, S., & Utomo, S. B. (2019). The implementation of PBL integrated with STEM in the material of temperature and its changes to the improvement of students ' creative thinking skills and learning results. *Journal of Educational Science and Technology*, *5*(3), 260–267. https://doi.org/10.26858/est.v5i3.10899

Marti, M., Syamswisna, S., & Panjaitan, R. G. P. (2014). Efektivitas pembelajaran kooperatif tipe NHT (numbered heads together) dengan media visual terhadap hasil belajar siswa pada materi organisasi kehidupan di kelas VII SMP Rehoboth [The effectiveness of cooperative learning type NHT (numbered heads together. *Jurnal Pendidikan Matematika Dan IPA*, *5*, 21–28. https://doi.org/10.26418/jpmipa.v5i2.13336

Maryani, E., Muchlis, M., & Jamaluddin, J. (2016). Implementasi model Pembelajaran Advance Organizer Menggunakan Animasi ditinjau dari Minat Belajar Terhadap Hasil Belajar Kognitif Siswa Kelas VII pada Pelajaran IPA di SMPN 1 Batukliang Tahun Ajaran 2014/2015. *Jurnal Penelitian Pendidikan IPA*, *2*(1), 65–76. https://doi.org/10.29303/jppipa.v2i1.34

Nugraheni, W. (2018). Peningkatan kemampuan mendeskripsikan Pposes pembentukan bayangan melalui media animasi pada siswa kelas VIII-G SMPN 1 Puncu [Improving the ability to describe the shadow formation process through animation media for students in class VIII-G SMPN 1 Puncu]. *Jurnal Penelitian Pendidikan IPA*, *3*(2), 77. https://doi.org/10.26740/jppipa.v3n2.p77-81

Nursamsu, N., & Kusnafizal, T. (2017). Pemanfatan media pembelajaran ICT sebagai kegiatan pembelajaran siswa di SMP Negeri Aceh Tamiang [Utilization of ICT learning media as student learning activities at SMP Negeri Aceh Tamiang]. *Jurnal IPA Dan*

Pembelajaran IPA, *1*(2), 165–170. https://doi.org/10.24815/jipi.v1i2.9691

Qosyim, A., & Priyongo, F. V. (2017). Penerapan media pembelajaran interaktif menggunakan flash untuk materi sistem gerak pada manusia kelas VIII [Application of interactive learning media using flash for human movement system material in class VIII]. *Jurnal Penelitian Pendidikan IPA*, *2*(2), 38–44. https://doi.org/10.26740/jppipa.v2n2.p38-44

Rizal, K., Saminan, S., & Rahmatan, H. (2017). Pemanfaatan audio visual berbasis discovery learning terhadap peningkatkan keterampilan berpikir kritis. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *5*(2), 57–65. https://doi.org/10.24815/jpsi.v5i2.9818

Rizqy, R. Z. (2019). *Analisis Integrasi Data pada Pangkalan Data Kekayaan Intektual (PDKI Indonesia) Mengenai Paten dan Merek Melalui Sinta 2*. ILKOM UNSRI.

Rohmawati, E., Widodo, W., & Agustini, R. (2018). Membangun kemampuan literasi sains siswa melalui pembelajaran berkonteks socio-scientific issues berbantuan media weblog [Building students' scientific literacy skills through learning in the context of socio-scientific issues using weblog media]. *Jurnal Penelitian Pendidikan IPA*, *3*(1), 8–14. https://doi.org/10.26740/jppipa.v3n1.p8-14

Safitri, I., Pasaribu, R., Simamora, S. S., & Lubis, K. (2019). The effectiveness of android application as a student aid tool in understanding physics project assignments. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 512–520. https://doi.org/10.15294/jpii.v8i4.19433

Sari, Y. K., Susilowati, S. M. E., & Ridlo, S. (2013). Efektivitas penerapan metode quantum teaching pada pendekatan jelajah alam sekitar (JAS) berbasis karakter dan konservasi [The effectiveness of applying the quantum teaching method to the character-based and conservation-based nature exploration approach . *Unnes Journal of Biology Education*, *2*(2). https://doi.org/10.15294/jbe.v2i2.2850

Saripudin, E., Sari, I. J., & Mukhtar, M. (2018). Using macro flash animation media on motion material to improve learning achievement for learning science in junior high school. *Jurnal Penelitian Dan Pembelajaran IPA*, *4*(1), 68–75. https://doi.org/10.30870/jppi.v4i1.3316

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.1017/CBO9781107415324.004

Suprianto, S., Kholida, S. I., & Andi, H. J. (2016). The effect of the contextual teaching and learning (CTL) approach assisted by PowerPoint media on improving science learning outcomes in physics. *Jurnal Penelitian Dan Pembelajaran IPA PENGARUH*, *2*(2), 166–175. https://doi.org/10.30870/jppi.v2i2.427

Sutarman, A. (2016). Pemanfaatan pembelajaran berbasis komputer model CD interaktif tutorial unutk meningkatkan hasil belajar [Utilization of computer-based learning interactive CD tutorial models to improve learning outcomes]. *Jurnal Penelitian Dan Pembelajaran IPA*, *2*(1), 81–98. https://doi.org/10.30870/jppi.v2i1.739

Utomo, T. W. (2016). Meta analisis dalam studi kebijakan (pendekatan kualitatif). *Forum Penguatan Kelembagaan Pusat Data Dan Informasi Penelitian Hukum Dan HAM*.

Wahono, R. S. (2015). A systematic literature review of software defect prediction: Research trends, datasets, methods and frameworks. *Journal of Software Engineering*, *1*(1), 1–16. https://doi.org/10.3923/jse.2007.1.12

Wright, R. W., Brand, R. A., Dunn, W., & Spindler, K. P. (2007). How to write a systematic review. *Clinical Orthopaedics and Related Research*, *455*, 23–29. https://doi.org/10.1097/BLO.0b013e31802c9098