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Competencies of Chemistry Teachers and Prospective Teachers: A Literature Review

Alessandro Jeremi Manarisip[1*], Rabiatul Adawiyah[1], Sri Handayani[1]

[1] Department of Science Education, Faculty of Science and Mathematics, Yogyakarta State University, Yogyakarta, Indonesia.

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Corresponding Author:
Alessandro Jeremi Manarisip
alessandrojeremi.2022@student.uny.ac.id

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Abstract: The role and function of teachers as professionals is to implement the national education system and realize national education goals, which is to develop the potential of students. Therefore, the competence and professional development of teachers must be in line with the way they carry out learning, especially in chemistry subjects. Where this subject is one of the subjects that most students are less interested in. The focus of this research is to collect information about the outcome of research that discusses the competence of chemistry teachers and prospective teachers, the research design uses a literature review with a qualitative descriptive approach. Reviewed 3 selected journals registered in Science and Technology Index (SINTA), and 17 SCOPUS indexed international journals. The collection of articles starts from 2016 to 2023. The most frequently used research type is qualitative with a case study research type, the most frequently used data collection instrument is observation with triangulation techniques. Chemistry teacher competencies needed at this time are PCK, CK, AK, PCK_CCC, TPASK, topic-specific PCK (TSPCK), argumentation, laboratory skill competence, technological knowledge, professional competence, and competence in organizing lesson study.

Keywords: Chemistry Teacher; Competence; Literature Review.

Introduction

Over the past few years, there has been a change from the traditional teacher-dominated approach to science teaching to a more activity-focused and student-centered approach complemented by activities that combine science teaching-learning activities and practical learning. Teacher knowledge is also indisputable in the teaching process. Teachers must have an adequate understanding of the subject matter being taught. However, having a grasp of the subject matter alone does not guarantee a teacher's success; proficiency in the teaching methods of the subject in question is also a necessity (Kiran and Boz. 2020).

Teachers play a crucial professional role in putting the national education system into practice and achieving the goals of education, which include helping students reach their full potential and become competent, creative, and self-sufficient individuals (Widyatiningtyas, 2004; British Council Federation of Teachers & CUPE British Council, 2009). During class periods, educators design experiences for their pupils (Sexton, 2015).

According to Avalos (2011), a teacher can enhance their professional skills by participating in professional development activities, which are essential components in research. Proficiency in managing the course of instruction is one aspect of pedagogical competence that might influence a teacher's work style (Sisdiknas, 2006). According to Rusdiana & Heryati (2015) there are 4 competencies that must be possessed by a teacher, namely pedagogic, social, personality, and professional. The main competency that teachers must have so that learning is effective and dynamic is pedagogical competence. Teachers must learn maximally to master this pedagogical competence in theory and practice so that in teaching they do not experience difficulties (Siregar. 2012).

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Research conducted by Akin and Kondakci (2018) explains that as experience increases, teachers can improve PCK and its application in the classroom. Teaching experience may have a role in science teachers' teaching orientation. The more teaching experience they gain, the more different orientations they have.

In the education process at school, chemistry is one of the compulsory subjects that must be studied in high school. Chemistry is a subject that most students are less interested in. This is inseparable from the way books present material, the way teachers teach chemistry, public information received by students, and the purpose of students learning chemistry (Subagia. 2014). For this reason, teachers' competencies and professional development should match their approach to teaching. (Avalos, 2011), playing their roles and functions as knowledgeable and skilled teachers in teaching and learning.

This review aims to analyze various literature used about the competence of chemistry teachers and prospective teachers over the past 8 years, Research Focus chemistry teacher competence, research type, research instruments used, data analysis methods used, the number of research samples, and analyze various components of chemistry teacher competence. Researchers focused on all articles on the theme of chemistry teacher competence that have been published and accredited by the Science and Technology Index (SINTA) and SCOPUS indexed articles from 2016 to 2023.

Method

This research uses a qualitative descriptive approach, with a literature review, namely the acquisition of research data by utilizing library sources (Pringgar and Sujatmiko. 2020). Then the study is carried out, data collection, followed by the discovery of results and conclusions. The collection of journals that discuss the problems of chemistry teacher education and competence is carried out by reviewing 3 selected journals listed on the *Science and Technology Index* (SINTA), and 17 international journals listed on *Google Scholar* by SCOPUS. Starting from 2016 to 2023. The keywords the author used were "chemistry teacher competence", "Chemistry Teacher Knowledge".

Result and Discussion

Journal Name and Index

The order of the Ministry's Scopus and SINTA rankings is from highest to lowest with a time span of 2016 - 2022. Table 1 presents the number of Journal name, index, and Authors

Table 1. Journal name, index, and Authors

Number of Journals	Journals Name	Index	Authors
13	Chemistry Education Research and Practice	Q1	(Karatas, 2016; Mavhunga, 2016); Cigdemoglu et al, 2017; Gabby et al, 2017); Uzuntiryaki-Kondakci et al, 2017; Akin & Uzuntiryaki-Kondakci, 2018; Wei & Liu, 2018; Ekiz-Kiran & Boz, 2020; Chen & Chen, 2021; Tal et al, 2021; He et al, 2021; Boothe et al., 2023; Oztay et al., 2023)
2	Education Science	Q1	(Hernández-Ramos et al., 2023; Peretz et al., 2023)
1	Journal of Turkish Science Education	Q2	(Copriady, 2018)
1	PER	Q3	(Arslan et al,. 2022)
1	Jurnal Pendidikan Kimia Indonesia	SINTA 2	(Solikhin & Rohiat, 2023)
1	QUANTUM: Jurnal Inovasi Pendidikan Sains	SINTA 3	(Pongkendek & Marpaung, 2020)
1	Jurnal Inovasi Pendidikan Kimia	SINTA 3	(Mulyatun, 2017)

This research used 7 journal publications, including 4 international publications indexed by Scopus Q1 - Q3, and 3 local publications indexed by SINTA 2 & 3. International publications used 13 article of Royal Society of Chemistry (RSC) index Q1, 2 article of Education Science index Q1, 1 article of Turkish Science Education index Q2, 1 article of Participatory Educational Research (PER) index Q3. Local publications use 1 article Indonesian Chemical Education journal index SINTA 2, 1 article of QUANTUM: Journal of Science Education Innovation index SINTA 3, and 1 article of Jurnal Inovasi Pendidikan Kimia.

Research Focus

According to the analysis of 20 journals, the research focus of each journal was obtained, namely discussing

teaching & learning, argumentation, PCK_CCC (pedagogic content knowledge_chemistry core competencies), assessment knowledge (AK), professional competence, TPASK (technological pedagogical science knowledge), pedagogical content knowledge (PCK), chemistry laboratory, and pedagogic competence. Of the five research focuses, it was found that PCK was the most widely studied in chemistry teacher competence. Figure 1 shows the number of Research Focuses for chemistry teacher competencies

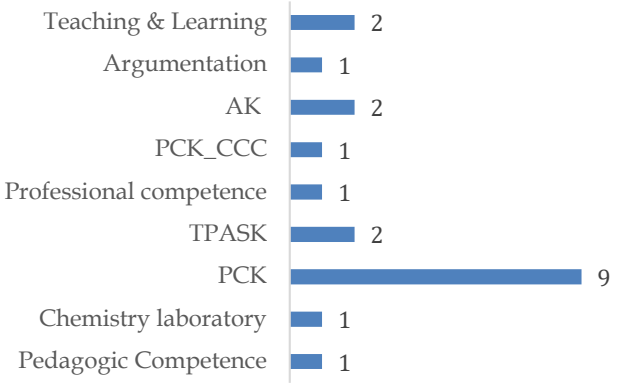

Figure 1. Research Focus chemistry teacher competence

Research Type

The type of research is one of the things that can determine the focus of a study. Figure 2 shows information about the various types of research used to determine the competence of chemistry teachers. One aspect that can determine the focus of a study is the type of research used. In Figure 2, there are 12 journals that use qualitative research approaches, 5 journals that use mixed methods, and 3 journals that use quantitative approaches to explore issues surrounding chemistry teacher competencies. In the 20 journals investigated, qualitative research dominates and is frequently used to investigate the topic of chemistry teacher education and competence. Qualitative research is an approach used to explore and explore the meaning interpreted by certain individuals or groups as part of social issues.

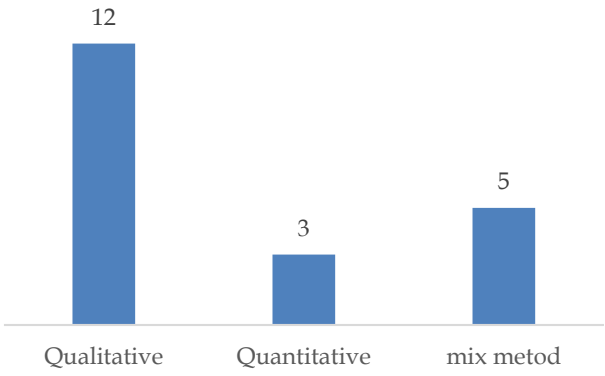

Figure 2. Research Type

The abundant use of this type of qualitative research occurs because this method tends to cover important aspects of research, such as in-depth understanding of the phenomenon that is the focus of the research, as well as involving the researcher as the main instrument in data collection and analysis, as described by Creswell (2018).

Research Instruments

Research instruments are tools or methods used by researchers to collect data needed in a study. These instruments can vary, depending on the type of research, the purpose of the research, and the data to be collected. When conducting research requires instruments to assist in collecting data. Figure 3 shows information about the various research instruments used to examine the competence of chemistry teachers.

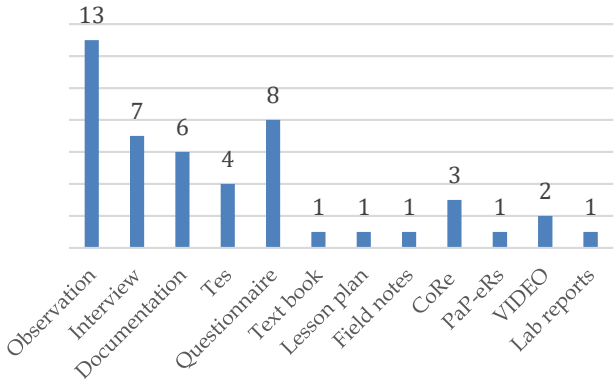

Figure 3. Research Instruments

Based on Figure 3 shows information on various research instruments used to examine the competence of chemistry teachers including observation, documentation interviews, tests, questionnaires, textbooks, lesson plans, field notes, CoRe (content representation), PaP-eRs (professional-experience repertoires), videos, lab reports. Observational instruments were most widely used in the 20 articles reviewed, with 13 articles using these instruments. Observation is an action where the researcher goes directly to the field to observe the behavior and activities of each individual at the research location by recording or recording each data component in a structured or semistructured manner (Creswell. 2018).

Data Analysis Method

Data analysis method is a systematic process for transforming, organizing, and interpreting data that has been collected in research. Determining the level of validity of a study can occur if the selection of data analysis techniques is used appropriately. Figure 4 shows the various data analysis techniques used by

researchers to examine the competence of chemistry teachers.

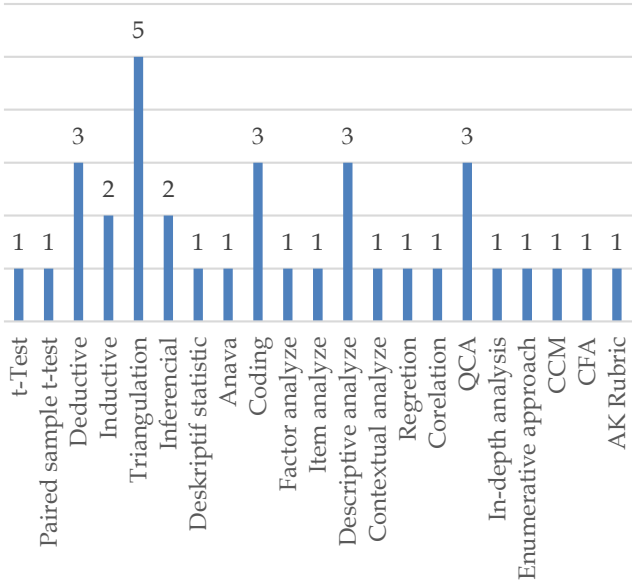

Figure 4. Data Analysis Method

Figure 4 shows various data analysis methods, including t-test, paired sample t-test, deductive, inductive, triangulation, inferencial, descriptive statistics, anava, coding, factor analysis, item analysis, descriptive analysis, contextual analysis, regression, correlation, QCA (qualitative content analysis), in-depth analysis, enumerative approach, CCM (constant comparative method), CFA (confirmatory factor analysis), and AK rubric (assessment knowledge). Triangulation is the most widely used data analysis method by researchers.

Triangulation is defined as the use of multiple data collection results to match and validate the data in strengthening the results of the study. The advantage of using triangulation aims to deepen the data where other methods can be used if one of the methods in the study has weaknesses. (Satori & Komariah. 2011)

Research Sample

A research sample is a group of individuals or elements taken from a larger population that represents the group to be analyzed in a research study. Figure 5 shows the number of research samples used in the 20 journals reviewed. The research samples include 9 graduate students, 316 pre-service teachers, and 735 teachers.

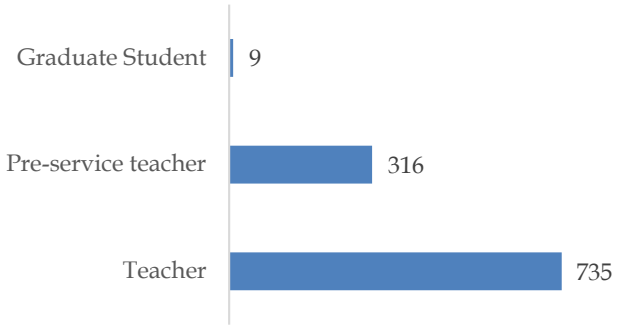

Figure 5. Research Sample

Chemistry Teacher Competence

Based on a review of 20 journals found that chemistry teacher competencies needed at this time are PCK, CK, AK, PCK_CCC, TPASK, topic-specific PCK (TSPCK), argumentation, laboratory skill competence, technological knowledge, professional competence, and competence in organizing lesson study. The pedagogical competencies of teachers analyzed by Pongkendek & Marpaung (2020) include learning planning, learning implementation, and learning evaluation.

Research conducted by Uzuntiryaki-Kondakci et al,. (2017); Akin & Uzuntiryaki-Kondakci (2018); Ekiz-Kiran & Boz (2020); Chen & Chen (2021); Oztay et al., (2023) explain that PCK components include science teaching orientation (STO), knowledge of learners (KoL), knowledge of curriculum (KoC), knowledge of instructional strategies (KoIS), Knowledge of assessment (KoA). The PCK components used by Boothe et al. (2023) include knowledge of the science curriculum, knowledge of student understanding in science, knowledge of instructional strategies for teaching science, knowledge of assessment of science learning, and teacher efficacy.

According to Chen & Chen (2021), chemistry teachers' PCK in practicum can come from nine different sources, namely learning experiences, pre-service training, in-service training, classroom observation, peer guidance, professional journals, online learning resources, teaching practices, and curriculum materials. Research conducted by Akin & Uzuntiryaki-Kondakci (2018) explains that the interaction between PCK components includes STO-KoIS interplay, STO-KoC, STO-KoL, STO-KoA, KoL-KoIS, KoL-KoC, KoL-KoA, KoC-KoIS, KoC-KoA, KoA-KoIS. Wei & Liu (2018) provided an explanation of the connection between PCK in instruction and practical labor. This link includes the approach to teaching science, the way that students learn from their practical work, and the instructional strategies used in that activity. Uzuntiryaki-Kondakci et al., (2017) explained that in the PCK component

measured, the teacher self-regulation phase includes: forethought phase, performance phase, self-reflection.

Peretz et al. (2023) describe a knowledge assessment rubric for tasks developed by teachers themselves: chemistry and sustainability, diversity of thinking skills, diversity of system aspects, diversity of visual representations. As for He et al (2021) explain the components in the assessment, namely CK assessment using rubrics (1) subject matter expertise, (b) the quantity of chemistry-related comprehension levels applied, and (c) any special features or visual aids incorporated. PCK assessment uses rubrics (1) number of levels of understanding of chemistry, (2) level of thinking, (3) context-based sustainable chemistry material. The PCK rubric includes: Variety of activities and thinking skills required, Level of adaptability and applicability for students, Relationship of proposed tasks to sustainable chemistry.

He et al. (2021) explained the instrument construct of PCK_CCC includes knowledge of the orientation of chemistry teaching and learning (KOTLC), knowledge of the chemistry curriculum (KCC), knowledge of chemistry teaching instructional strategies (KISTC), knowledge of chemistry teaching assessment (KACL), and knowledge of student understanding in chemistry (KSUC).

Gabby et al. (2017) explain that teacher competencies are enhanced to integrate technology into pedagogical practice in a meaningful way to promote skills in the present. Solikhin & Rohiat, 2023 explained that These seven aspects are TK (technological knowledge), PK (pedagogical knowledge), CK (content knowledge), TPK (technological pedagogical knowledge), PCK (pedagogical content knowledge), TCK (technological content knowledge), and TPACK (technological, pedagogical, and content knowledge). Hernández-Ramos et al. (2023) explained that there are relevant elements to produce an effective learning environment mediated by technology, namely LMS (learning management systems), learning goals, content, teaching methods, monitoring and evaluation, collaboration and social interaction, effective organization of time.

Research conducted by Karatas (2016) explains that laboratory skill competencies measured include solution problems, laboratory equipment usage, solution preparation, laboratory safety. Copriady (2018) explains that teacher competence in designing practicum sessions in the laboratory includes planning, implementation, and assessment in conducting practicum sessions in chemistry laboratories.

The components to measure TSPCK used by Mavhunga (2016) include learners' prior knowledge, curricular saliency, exploration of concepts and identifying current issues, knowledge of representations, conceptual teaching strategies, and conceptualization.

Arslan (2022) explains that teacher professional development includes lesson introduction activities, didactic structure of the lesson, classroom communication and management, student-centered approach, assessment-evaluation approach.

Competencies assessed in compiling lesson study include (1) formulation of learning objectives (2) selection and organization of teaching materials, (3) selection of learning resources / learning media, (4) learning scenarios / activities, (5) assessment of learning outcomes (Mulyatun, 2017).

Conclusion

The literature review on 20 articles that discuss chemistry teacher competence in the 21st century uses 17 international journals indexed by Scopus Q1-Q3 and 3 local journals indexed by SINTA 2-3. The findings of the research focus on the competence of chemistry teachers include discussions of teaching & learning, argumentation, PCK_CCC, AK, professional competence, TPASK, (PCK), chemistry laboratory, and pedagogic competence. Journals with discussions of PCK are the most widely used in this literature review. For the type of research used, namely using qualitative, quantitative, and mixed method approaches, with the most widely used research approach being 12 journals that use qualitative. The use of research instruments in this literature review includes observation, documentation interviews, tests, questionnaires, textbooks, lesson plans, field notes, PaP-eRs (professional-experience, CoRe (content representation), repertoires), videos, lab reports. Data analysis methods included t-test, paired sample t-test, deductive, inductive, triangulation, inferencial, descriptive statistics, anava, coding, factor analysis, item analysis, descriptive analysis, contextual analysis, regression, correlation, QCA, in-depth analysis, enumerative approach, CCM, CFA, and AK rubric. The research sample consisted of 9 graduate students, 316 pre-service teachers, and 735 teachers. PCK components include STO, KoL, KoC, KoIS, KoA. Components in the assessment include CK assessment, PCK assessment. PCK_CCC instrument includes KOTLC, KCC, KISTC, KACL, and KSUC. There are several relevant elements to produce an effective learning environment mediated by technology. Laboratory skill competencies measured include problem solution, laboratory equipment usage, solution preparation, laboratory safety.

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References

Akin, F.N., & Kondakci, E.Z. (2018). The nature of the interplay among components of pedagogical content knowledge in reaction rate and chemical equilibrium topics of novice and experienced chemistry teachers. *Chem. Educ. Res. Pract*, 19. 80—105. https://doi.org/10.1039/C7RP00165G

Arslan, A. S., Faik Karatas, O., Unal, S., & Aslan, A. (2022). The effects of group mentoring on teachers' classroom activities: an instrumental case study. *Participatory Educational Research*, 9 (5), 390-413. http://dx.doi.org/10.17275/per.22.120.9.5

Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Journal of Teaching and Teacher Education*, 27, 10-20. https://doi.org/10.1016/j.tate.2010.08.007

Boothe, J. R., Zotos, E. K., Shultz. G. V. (2023). Analysis of post-secondary instructors' pedagogical content knowledge of organic acid–base chemistry using content representations. *Chem. Educ. Res. Pract*., 24, 577. http://dx.doi.org/10.1039/D2RP00253A

British Council Teachers' Federation (BCTF) & CUPE BC. (2009). *Roles and responsibilities of teachers and teacher assistants/education assistants*.

Chen, B., Chen, L. (2021). Examining the sources of high school chemistry teachers' practical knowledge of teaching with practical work: from the teachers' perspective. *Chem. Educ. Res. Pract*., 22, 476. https://doi.org/10.1039/D0RP00246A

Chochran, S.M. (2006). *Policy, practice and politics in teacher education. Editorial from the journal of teacher education*. California: A joint publication of Crown Press. Sage Publication Company and Serving Leader Thousand Oaks. p. XIIV.

Cigdemoglu C,H. O. Arslanb & A. Cam. 2017. Argumentation to foster pre-service science teachers' knowledge, competency, and attitude on the domains of chemical literacy of acids and bases. *Chem. Educ. Res. Pract*, 18, 288—303. https://doi.org/10.1039/C6RP00167J

Copriady, J., Rery, R. U., Zulnaidi, H., Alimin, M. (2018). Contribution toward practical design to improve the planning, implementation, and assessment of the instruction of chemistry teachers. *Journal of turkish science education*, 15 (3), 41-50. Retrieved from https://www.tused.org/index.php/tused/article/view/245

Creswell John W. (2018). *Research design pendekatan metode kualitatif, kuantitatif, dan campuran*. Pustaka Belajar: Yoyakarta.

Gabby, S., Avargil, S., Herscovitza, O., & Dor, Y. J. (2017). The case of middle and high school chemistry teachers implementing technology: using the concerns-based adoption model to assess change processes. *Chem. Educ. Res. Pract*, 18, 214—232. https://doi.org/10.1039/C6RP00193A

He, P., Zheng, C., & Li, T. (2021). Development and validation of an instrument for measuring Chinese chemistry teachers' perceptions of pedagogical content knowledge for teaching chemistry core competencies. *Chem. Educ. Res. Pract*, 22, 513–531. http://dx.doi.org/10.1039/C9RP00286C

Hernández-Ramos, J., Rodríguez-Becerra, J., Cáceres-Jensen, L., & Aksela, M. (2023). Constructing a novel e-learning course, educational computational chemistry through instructional design approach in the tpask framework. *Educ. Sci*., 13, 648. https://doi.org/10.3390/educsci13070648

Karatas F. O. (2016). Pre-service chemistry teachers' competencies in the laboratory: a cross-grade study in solution preparation. *Chem. Educ. Res. Pract*, 17, 100—110. https://doi.org/10.1039/C5RP00147A

Kiran B. Ekiz & Boz Yezdan. (2020). Interactions between the science teaching orientations and components of pedagogical content knowledge of in-service chemistry teachers. *Chem. Educ. Res. Pract,* 21. 95—112. https://doi.org/10.1039/C9RP00092E

Mulyatun. (2017). Lesson study: strategi alternatif peningkatan kompetensi calon guru kimia. *Jurnal Inovasi Pendidikan Kimia*, 11 (1), 1816 – 1827. https://doi.org/10.15294/jipk.v11i1.9709

Oztay, E. S., Ekiz-Kiran, B., Boz, Y. (2023). Revealing the development of interaction among components of pedagogical content knowledge in teaching chemical equilibrium. *Chem. Educ. Res. Pract*., 24, 624. https://doi.org/10.1039/D2RP00159D

Peretz, R., Dori, D., & Dori, Y. J. (2023). Investigating chemistry teachers' assessment knowledge via a rubric for self-developed tasks in a food and sustainability context. *Educ. Sci*. 13, 308. https://doi.org/10.3390/educsci13030308

Pongkendek, J. J., Marpaung, D. N. (2020). Analisis kompetensi pedagogik guru kimia sma di distrik Merauke dalam implementasi kurikulum 2013. *QUANTUM: Jurnal Inovasi Pendidikan Sains*, 11 (1),

27-35. http://dx.doi.org/10.20527/quantum.v11i1.7381

Pringgar R, F & Sujatmiko B. (2020). Penelitian kepustakaan (Library Research) Modul Pembelajaran Berbasis Augmented Reality Pada Pembelajaran Siswa. *Jurnal IT-EDU*, 05(01), 317-329. Retrieved from https://ejournal.unesa.ac.id/index.php/it-edu/article/view/37489/

Rusdiana, & Heryati, Y. (2015). *Pendidkan Profesi Keguruan*. Bandung: Pustaka Setia

Satori, D., & Komariah, A. (2011). *Metodologi Penelitian Kualitatif. Bandung*: Alfabeta

Sexton, S. (2015). Teaching the future teachers: a teacher educator's self-study in making science relevant, useful and meaningful for New Zealand pre-service teachers. *Journal of Education in Science, Environment and Health*, 1(1), 10-19. http://dx.doi.org/10.21891/jeseh.94738

Siregar, R.A. (2012). Analisis kompetensi pedagogik guru kimia dan hubungannya dengan hasil belajar kimia siswa sma di kota Padangsidimpuan. *Jurnal Pendidikan Kimia Edisi 8*. 1(2). 5-12.

Sisdiknas. (2006). *Law of the Republic of Indonesia Number 14 Year 2005 About Teachers and Lecturers.* Bandung: Citra Umbara.

Solikhin, F., & Rohiat, S. (2023). The tpack profile of chemistry prospective teachers in microteaching class, university of Bengkulu. *Jurnal Pendidikan Kimia Indonesia,* 7(1), 19-28. https://doi.org/10.23887/jpki.v7i1.49009

Subagia, I.W. (2014). *Paradigma Baru Pembelajaran Kimia Sma.* Seminar Nasional FMIPA UNDIKSHA IV

Tal, M., Herscovitz, O., & Dor, Y. J. (2021). Assessing teachers' knowledge: incorporating context-based learning in chemistry. *Chem. Educ. Res. Prac*, 22, 1003–1019. https://doi.org/10.1039/D0RP00359J

Uzuntiryaki-Kondakci, E., Demirdogen, B., Akin, F. N., Aysegul T., & Aydın-Gunbatar, S. (2017). Exploring the complexity of teaching: the interaction between teacher self-regulation and pedagogical content knowledge. *Chem. Educ. Res. Pract*, 18, 250—270. https://doi.org/10.1039/C6RP00223D

Wei, B., & Liu, H. (2018). An experienced chemistry teacher's practical knowledge of teaching with practical work: the PCK perspective. *Chem. Educ. Res. Pract*., 19, 452. https://doi.org/10.1039/C7RP00254H

Widyatiningtyas. R. (2004). (Teachers' role in doing assessment for processing skills) Peranan Guru Dalam Melakukan Penilaian Keterampilan Proses. Educare, *Jurnal Pendidikan dan Budaya*, 2 (2), 8-17