Jurnal Ilmiah Sekolah Dasar
Volume 6, Number 1, 2022 pp. 136-144
P-ISSN: 2579-3276 E-ISSN : 2549-6174
Open Access: https://dx.doi.org/10.23887/jisd.v6i1.43856

Science Content Knowledge of Pre-Service Teachers in Biology Elementary School Level

Rif'at Shafwatul Anam[1]*

[1] Program Studi Pendidikan Guru Sekolah Dasar, Universitas Terbuka, Tangerang, Indonesia

ARTICLE INFO

Article history:
Received November 12, 2021
Accepted Juanuary 21, 2022
Available online February 25, 2022

Kata Kunci:
Calon Guru SD, Science Content Knowledge, Biologi

Keywords:
Pre-Service Teachers, Science Content Knowledge, Biology

ABSTRAK

Harapan terhadap guru sekolah dasar yang berkualitas di Indonesia sangat tinggi. Masyarakat semakin sadar bahwa pendidikan di sekolah dasar merupakan bagian penting dalam memperkenalkan suatu disiplin ilmu kepada siswa, salah satunya adalah sains. Untuk memberikan pembelajaran IPA yang optimal, guru harus memiliki Science Content Knowledge (SCK) yang mumpuni agar tidak terjadi miskonsepsi dan kebingungan di kalangan siswa. Penelitian ini bertujuan untuk menganalisis penguasaan SCK calon guru terhadap mata pelajaran biologi di tingkat SD. Metode penelitian dalam penelitian ini adalah metode deskriptif dengan menggunakan desain survey. Data didapatlkan dari 284 peserta program pendidikan guru sekolah dasar pada akhir semester. Instrumennya berupa tes pilihan ganda dengan empat pilihan jawaban dengan 40 soal. Instrumen tersebut kemudian diberikan kepada partisipan dan dilakukan analisis dengan menghitung presentasenya serta memasukkannya ke dalam kategori yang telah ditentukan. Penelitian ini menemukan bahwa penguasaan SCK guru prajabatan perlu diperhatikan karena kategori rerata pemahamannya berada pada kategori "Sangat Kurang" dan "Kurang". Penelitian ini menyarankan perlu adanya program profesional baik guru maupun guru prajabatan yang dapat memadukan SCK dan pedagogi agar pembelajaran yang diberikan lebih optimal dan memberikan pengalaman belajar yang baik.

ABSTRACT

Expectations for qualified primary school teachers in Indonesia are very high. The public is aware that education in elementary schools is an essential part of introducing a scientific discipline to students, one of which is science. To provide optimal science learning, teachers must have qualified Science Content Knowledge (SCK) so that students have no misconceptions and confusion. This study aims to analyze the mastery of prospective SCK teachers on biology subjects at the elementary level. The research method in this study is a descriptive method using a survey design. Data were obtained from 284 primary school teacher education program participants at the end of the semester. The instrument is a multiple-choice test with four answer choices with 40 questions. The device was then given to the participants and analyzed by calculating the percentage and putting it into a predetermined category. This study found that the mastery of pre-service teacher SCK needs to be considered because the average category of understanding is in the "Very Poor" and "Less" types. This study suggests the need for a professional program for both teachers and pre-service teachers who can combine SCK and pedagogy so that the learning provided is more optimal and offers a good learning experience.

1. INTRODUCTION

Teachers are also called educators and teachers. A teacher is a professional position that requires technical skill requirements and certain personality attitudes, all of which can be obtained through the teaching and learning process and training (Buchari, 2018; Montolalu & Langi, 2018; Risnani, 2019). The teacher is responsible for student education (Sugihartini et al., 2018; Suprihatin, 2015; Wahyono et al., 2020). A professional educator has the knowledge, skills, and professional attitudes capable and loyal to develop their profession. In addition, teachers become members of educational professional organizations, adhere to the professional code of ethics, participate in communicating collaborative professional development efforts (Darmadi, 2016; Hanifah, 2018; Salmia & Yusri, 2021). The work of teachers can be seen as a profession that, as a whole, must have a good personality and be mentally tough because they can

Corresponding author
*E-mail addresses: rifat.official@ecampus.ut.ac.id (Rif'at Shafwatul Anam)

be an example for their students and the surrounding community (Agustina, 2018; Hasfira & Marelda, 2021; Mulyana, 2017). The duties and responsibilities of a teacher/teacher are to manage to teach more effectively, dynamically, efficiently, and positively. It is characterized by awareness and active involvement between the two teaching subjects, the teacher as the initiator and director and mentor, while students experience and are actively involved in gaining self-change in teaching (Agustini et al., 2020; Hartanti & Yuniarsih, 2018).

Society certainly needs competent teachers; therefore, preparing qualified teachers is a concern in most countries. *Teacher knowledge* is a complex phenomenon that is difficult to define. There is almost no consensus on what teachers' knowledge is and what competent teachers should know and be able to do; however, usually, the teacher's competence will depend on the policies made by the school (Hilpert & Marchand, 2018; Luik et al., 2018). There are no standards in determining teacher competence. In that case, it will undoubtedly result in the quality of education/learning that is not optimal. Even though every country ensures that highly qualified teachers teach all children, it is considered the primary goal of the education system worldwide (Kind, 2019; Ríordáin et al., 2019). There is a lot of research and policymaking that tries to do its best to improve students' education, especially in science lessons. Still, unfortunately, there are only a few studies on how to increase teachers' science content knowledge (SCK) (Bates & Morgan, 2018; Firestone et al., 2020). The lack of teachers' SCK makes the teacher unable to teach science effectively (Fragkiadaki et al., 2019). Besides that, this can also cause misconceptions in students, and teachers are one of the leading causes of misunderstandings. If not corrected, these students will experience problems at the next level of education (Anam, Widodo, Sopandi, et al., 2019; Desstya et al., 2019).

SCK can be defined as knowledge of the subject to be taught, and this is also a significant prerequisite in providing learning to the student (Lohbeck et al., 2018; Paulick et al., 2016). Elementary school teacher SCK is a problem in many countries. Based on the results of a survey conducted by Trygstad et al (2013), only 33% of teachers feel prepared to teach science, and even fewer feel prepared for teaching physical science. We know that science is studied from elementary to high school level. *Science* is a lesson that is closely related to life and cannot be separated from it. Therefore, elementary school teachers must have good SCK because elementary school is an introductory level for students to understand science. Because of that, the SCK of elementary school teachers has been an issue of great concern for the science education community and educators (Al Sultan et al., 2018; Cofré et al., 2015; Harrell & Subramaniam, 2015).

One part of science that studies living beings and the process, such as humans, animals, plants, and interactions with the environment, is known as biology (Arum & Wahyudi, 2016; Jalil, 2016; Khoirudin, 2016). Biology has been studied by students from an early age and elementary school. Because biology is essential to students, students need to understand to know themselves and their environment. Therefore, teachers and pre-service teachers must have a good understanding of this matter (Mutakinati et al., 2018; Taştan et al., 2018). Because several studies show that the understanding of teachers / pre-service teachers is not better than that of students in physics science (Anam, Widodo, & Sopandi, 2019; Desstya et al., 2019). However, not many studies discuss the conception of teachers or pre-service teachers of science biology in elementary schools. Existing research on biology subjects generally discusses learning and teaching biology (Lewis, 2019; Subramaniam, 2019). In addition, previous research also revealed the right media and learning models for biology learning (Astatin & Nurcahyo, 2016; Wahyuni & Yokhebed, 2019; Wulandari et al., 2019). This study aims to find out how pre-service teachers conceptualize biology science at the elementary school level. Because SCK in biology science is essential to teachers or pre-service teachers in elementary school, SCK needs to improve, starting with the pre-service teachers. SCK will affect the confidence of teachers in teaching science (Norris et al., 2018; Widodo et al., 2017).

2. METHOD

This research is a descriptive study with a survey method (Atmowardoyo, 2018; Zapko et al., 2018). Participants in this study were 284 (two hundred and eighty-four) pre-service teachers in the Elementary School Teacher Education program at the last of the semester in Sumedang-Indonesia. The instrument used in this study was the concept of biology at the elementary school level with 40 (forthy) questions of multiple-choice format. The instrument was distributed online to participants at the end of the lecture. Table 1 will clearly show the concepts tested in this study.

Table 1. Concepts and dissemination of biology questions

No	Biology Concepts	Test Number			Total
1	Biodiversity	1	2	3	**3**

No	Biology Concepts	Test Number								Total
2	Green Plants	4	5	6						**3**
3	Symbiosis	7	8							**2**
4	Human Reproduction	9	10	11	12					**4**
5	Animal Reproduction	13	14	15	16	17				**5**
6	Plant Reproduction	18	19	20	21	22	23	24		**7**
7	Respiratory	25	26	27						**3**
8	Digestion	28	29	30	31	32	33	34	35	**8**
9	Blood	36	37	38	39	40				**5**

Participants in this study will be given two values, one (1) if they give the correct answer and zero (0) if they give the wrong answer. Responses will be averaged and categorized as 80-100 (very good), 70-79 (good), 60-79 (fair), 40-59 (poor) and 30-39 (very poor) (Anam, 2020). The methods used to collect data are interviews and questionnaires. The instrument used to collect data is a questionnaire. After completing the instrument, participants were asked questions about their responses related to the instruments. There are four questions given: 1) Are these questions for Elementary School Students' level? 2) Have you ever learned the concept of these instruments? 3) Can you answer the questions on the instruments? And 4) Are you sure of your answer?. The technique used to analyze the data is descriptive qualitative and quantitative analysis.

3. RESULT AND DISCUSSION

Result

The results of this study will be discussed starting from how the participants have SCK and how they respond to these instruments regarding biology at the elementary level. Analysis of the SCK category of participants in the concept of biology, namely; Biodiversity with a percentage of 30% (very poor), Green Plants with a percentage of 62% (enough), Symbiosis with a percentage of 32% (very poor), Human Reproduction with a percentage of 53 (less), Animal Reproduction with a percentage of 72 (good), Plant Reproduction with a percentage of 57% (less), Respiratory with a percentage of 33% (very poor), Digestion with a percentage of 49% (less), Blood with a percentage of 55% (less). In general, SCK pre-service teachers need to be improved. The proof is that their average mastery of biological concepts is in the "Very less" and "Less" categories. Only two of the nine concepts are in the "fair" category in the green plants' concept and "Good" in the animal reproduction concept. This result is certainly not in line with expectations, considering that the instruments they face are at the elementary level. In fact, they have studied these concepts from elementary school to high school. At least they have studied the concepts of biology for 9-12 years. Of course, this needs to be a concern for educators and researchers that they are learning and understanding during the educational process. Table 3 will provide more detailed information about the concepts asked in this research instrument.

Table 3. The participants' SCK and category in biology sub-concepts

Biology Concepts	Sub-Concepts	Number	Percentages (%)	Category
Biodiversity	Special characteristics of animals	1	16	Very Less
	Special characteristics of plants	2	53	Less
Plants	Animal classification	3	20	Very Less
	Photosynthesis	4	54	Less
	Impact of sunlight on plants	5	68	Enough
	Xylem and phloem functions	6	63	Enough
Symbiosis	Symbiosis of commensalism	7	12	Very Less
	Symbiosis of parasitism	8	52	Less
Human Reproduction	Male sexual hormones	9	69	Enough
	Female sexual hormones	10	31	Very Less
	Menopause	11	23	Very Less
Animal Reproduction	Male reproductive organs	12	88	Very Good
	Internal fertilization	13	91	Very Good
	Vegetative reproduction	14	65	Enough
		15	74	Good
	Metamorphosis	16	82	Very Good

Biology Concepts	Sub-Concepts	Number	Percentages (%)	Category
Plant Reproduction	Generative reproduction	17	49	Less
	Natural vegetative propagation	18	50	Less
		19	63	Enough
	Artificial vegetative propagation	20	51	Less
	Natural vegetative propagation	21	71	Good
	Artificial generative reproduction	22	57	Less
	Pollination	23	61	Enough
		24	46	Less
Respiratory	Nose	25	29	Very Less
	Lungs	26	16	Very Less
		27	54	Less
Digestion	Colon function	28	58	Less
	Ileum function	29	42	Less
	Use of a substance in the body	30	80	Very Good
	Function of substances in the body	31	61	Enough
	Appendicitis	32	39	Very Less
	Enzymes in digestion	33	25	Very Less
		34	31	Very Less
	Sequences of human digestion	35	56	Enough
Blood	Human blood circulation	36	25	Very Less
		37	37	Very Less
	Blood cells	38	65	Enough
	Blood disease	39	73	Good
	Oxygen rich and poor blood	40	75	Good

Table 3 shows that although the instrument provided was SCK for biology at the elementary school level, the participants' SCK mastery category was generally in "Very Less" of 30%, "Less" and "enough" of 27.5%. While in the "Good" and "Very Good" categories only 10%. The "Good" and "Very Good" categories are in the sub-concept of animal and plant reproduction, digestion, and blood. This study also indicates that SCK pre-service teachers need to be improved not only in physics (Anam, Widodo, & Sopandi, 2019; Widodo et al., 2017) but also in biology. But even in biology. After discussing SCK from pre-service teachers, the next discussion was about their responses to the four questions given about the instrument. The results are available in Table 4.

Table 4. The analysis of participant's responses

Response	Yes		No	
	Total	Percentages (%)	Total	Percentages (%)
Are these questions for Elementary School Students' level?	276	97	8	3
Have you ever learned the concept of these instruments?	269	95	15	5
Can you answer the questions on the instruments?	221	78	63	22
Are you sure of your answer?	125	44	159	56

Table 4 shows that the percentage of participants' responses from the first to the end of the question decreased. Most of them (97%) admitted that the instrument/questions given were at the elementary school level, then they also realized that they had learned the concepts on the instrument (95%). But when asked whether they could answer the instrument's questions, their response began to decline to 78%, especially when asked if they were sure of the answer, only 44% were sure of the answer. This study indicates that although the participants have studied biology from elementary to high school, their SCK does not prove it. Their understanding may not be better than that of elementary students themselves. A study conducted by Papageorgiou, Stamovlasis, & Johnson (2013) found similarities in SCK between teachers and students at the elementary and secondary levels.

Discussion

The impact of SCK on pre-service teachers or teachers who are generally in the "Very less" and "Less" categories at this basic level will harm the quality of teaching as a whole. Teachers cannot promote a creative discourse, and in fact, they are a source of confusion and misconceptions (Chen & Mensah, 2018; Widodo et al., 2017). Pre-service teachers experience this situation, but other research found that experienced teachers have little impact on their SCK (Großschedl, Mahler, Kleickmann, & Harms, 2014). Even though SCK is one of the main factors for teachers in providing their students' learning process, teachers who do not have a good SCK will not deliver a quality lesson (Anam et al., 2020; Fauth et al., 2019; Rollnick, 2017). In the learning process, the teacher does not only need to strengthen the SCK or CK. Teachers need to connect this CK with their understanding or ability in teaching or pedagogy. The teachers with the better CK will have the potential to generate capabilities from their PCK (Pedagogical Content Knowledge) (Verdugo et al., 2016). Several recent studies that discuss teacher SCK in various contexts generally show that elementary school teachers tend to have large gaps in their SCK, which is a significant obstacle in producing effective teaching (Nixon et al., 2019).

The teacher's SCK's weakness was the effect of inadequate preparation in the pre-service teachers' program (Diamond et al., 2013). Meanwhile, the new demands for elementary school teachers today are to involve students in authentic scientific inquiry and evidence-based discourse while providing a strong foundation for SCK (O. Lee et al., 2016). There is a long debate over whether elementary school teachers have adequate SCK for teaching science and how best to support them in acquiring this knowledge. Several studies have shown that elementary school teachers do not have the required scientific background, resulting in less preparedness to guide students in developing SCK and process skills and often convey misconceptions to their students (O. Lee et al., 2016; Rollnick, 2017). Several studies have shown that SCK of pre-service teachers and teachers in Elementary School still have limited content in some subject areas, concepts, which impact their self-confidence (T. D. Lee & Gail Jones, 2018; Pope, 2019; Schultz et al., 2017). Many elementary school teachers hold scientific ideas closer to students than scientists; besides, they also have similar misconceptions with the students they teach (Carrier, 2013; Kural & Kocakülah, 2016). The lack of SCK teachers was problematic. Teachers couldn't guide what they did not know, so there needs to be a focus on strengthening SCK in initial teacher training, in-service courses, and professional development (Fauth et al., 2019; Nixon et al., 2019). A summary of the findings regarding the lack of SCK in both pre-service teachers and teachers is spending time on lectures, relying more on textbooks and seat-work, avoiding class discussions and spontaneous questions from students, not asking causal problems, and failed to develop important scientific concepts (Nilsson & Karlsson, 2019; Pope, 2019).

The expectation for quality elementary school teachers in Indonesia is very high, even in all countries. At the same time, most of them are required to teach various subjects. In science lessons, they must be prepared with sufficient backgrounds in earth science, physics, and life sciences to guide authentic experiences that help students understand natural phenomena (Baumfalk et al., 2019; Luik et al., 2018). In addition, teachers also need to correct misunderstandings and respond effectively to students who have unique characteristics and diverse ideas. Elementary school teachers also need to develop a deep conceptual understanding of science while conveying science's nature by involving students in the scientific investigation (Subramaniam, 2019). Based on the study results, the SCK of pre-service teachers in elementary schools can be the majority in the "Less" category. It's not only experienced by pre-service, but teachers also experience the same thing as research found that the SCK of teachers was fairly low and needed to be an effort to increase the SCK of these elementary school teachers (Widodo et al., 2017). Moreover, education in elementary schools plays a significant role in building the foundation for the next level of education. Based on this study, even though the pre-service teachers have studied science for at least 9-12 years when given questions at the elementary school level, it does not appear that they have mastered the instrument's concepts. Moreover, their responses also showed that 95% of them had studied it before. Still, after working on the instrument, their responses were significantly reduced when asked about their confidence in their answers.

This study also suggests that to produce professional teachers, there should be a competency improvement program or professional development (PD) for teachers and pre-service teachers (Diamond et al., 2013; Lazarides et al., 2021). In addition, strengthening is not only for SCK teachers but also combined with qualified pedagogic abilities so that they can provide a strong learning process using SCK and good pedagogic content or what is called PCK (Benjamin et al., 2017; Bürgener & Barth, 2018). Elementary school teachers' problem in implementing a curriculum that is always developing, making learning media, connecting between subjects, technology, and the lack of PCK development that professional teachers are must-have. PCK is related to topics in specific disciplines (for example, "reproduction" in the biology domain) and how to teach these things to students in an ideal way so that the learning process is optimal. PCK also has a complex nature as a form of professional teacher knowledge that is highly topic, person, and

situation-specific. PCK is also knowledge to improve student learning in various ways (Nilsson & Karlsson, 2019).

4. CONCLUSION

This research shows that the pre-service SCK teachers of biology subjects at the elementary school level need to be improved. This condition is miserable, considering that they have studied science from elementary to high school, even during the lecture process. Moreover, based on their responses, most of them realized that these questions were at the elementary level and had already studied them. They even have shallow confidence in the answers given. Mastery of SCK will significantly affect the ability of pre-service teachers ability to teach science. This study suggests the need for a systematic program to improve and develop teachers' abilities in teaching science. With the increasing demands and needs of professional elementary school teachers, the program must start with pre-service teachers so that the results are even more optimal.

5. REFERENCES

Agustina, A. (2018). Menerapkan Penggunaan Bahan Ajar Bagi Guru Di SMA Negeri 3 Ogan Komering Ulu. *Journal Of Educational Studies*, *3*(1), 16–29. https://doi.org/10.30983/educative.v3i1.563.

Agustini, D., Lian, B., & Sari, A. P. (2020). School'S Strategy for Teacher'S Professionalism Through Digital Literacy in the Industrial Revolution 4.0. *International Journal of Educational Review*, *2*(2), 160–173. https://doi.org/10.33369/ijer.v2i2.10967.

Al Sultan, A., Henson, H., & Fadde, P. J. (2018). Pre-service elementary teachers' scientific literacy and self-efficacy in teaching science. *IAFOR Journal of Education*, *6*(1), 25–42. https://doi.org/10.22492/ije.6.1.02.

Anam, R. S. (2020). The Analysis of Science Process Skills on Pre-Service Elementary School Teachers. *Al Ibtida: Jurnal Pendidikan Guru MI*, *7*(2), 226. https://doi.org/10.24235/al.ibtida.snj.v7i2.6470.

Anam, R. S., Widodo, A., & Sopandi, W. (2019). Teachers, pre-service teachers, and students understanding about the heat conduction. *Journal of Physics: Conference Series*, *1157*(2), 1–7. https://doi.org/10.1088/1742-6596/1157/2/022012.

Anam, R. S., Widodo, A., & Sopandi, W. (2020). Conceptual Change Texts t o Improve Teachers ' Misconception at Verbal and Visual Representation on Heat Conduction Concept. *Jurnal Pendidikan Fisika Indonesia*, *16*(2), 63–71. https://doi.org/10.15294/jpfi.v16i2.20742.

Anam, R. S., Widodo, A., Sopandi, W., & Wu, H.-K. (2019). Developing a Five-Tier Diagnostic Test to Identify Students' Misconceptions in Science: An Example of the Heat Transfer Concepts. *Elementary Education Online*, *18*(3), 1014–1029. https://doi.org/10.17051/ilkonline.2019.609690.

Arum, T. S., & Wahyudi, W. (2016). Pengembangan Modul Pembelajaran Tematik Integratif Subtema Hubungan Makhluk Hidup Dalam Ekosistem Pendekatan Saintifik Untuk Kelas 5 Sd. *Scholaria : Jurnal Pendidikan Dan Kebudayaan*, *6*(3), 239. https://doi.org/10.24246/j.scholaria.2016.v6.i3.p239-250.

Astatin, G. R., & Nurcahyo, H. (2016). Pengembangan Media Pembelajaran Biologi Berbasis Adobe Flash untuk Meningkatkan Penguasaan Kompetensi pada Kurikulum 2013. *Inovasi Pendidikan IPA*, *2*(2), 165–176. https://doi.org/10.21831/jipi.v2i2.10966.

Atmowardoyo, H. (2018). Research Methods in TEFL Studies: Descriptive Research, Case Study, Error Analysis, and R & D. *Journal of Language Teaching and Research*, *9*(1), 197. https://doi.org/10.17507/jltr.0901.25.

Bates, C. C., & Morgan, D. N. (2018). Seven Elements of Effective Professional Development. *Reading Teacher*, *71*(5), 623–626. https://doi.org/10.1002/trtr.1674.

Baumfalk, B., Bhattacharya, D., Vo, T., Forbes, C., Zangori, L., & Schwarz, C. (2019). Impact of model-based science curriculum and instruction on elementary students' explanations for the hydrosphere. *Journal of Research in Science Teaching*, *56*(5), 570–597. https://doi.org/10.1002/tea.21514.

Benjamin, T. E., Marks, B., Demetrikopoulos, M. K., Rose, J., Pollard, E., Thomas, A., & Muldrow, L. L. (2017). Development and Validation of Scientific Literacy Scale for College Preparedness in STEM with Freshmen from Diverse Institutions. *International Journal of Science and Mathematics Education*, *15*(4), 607–623. https://doi.org/10.1007/s10763-015-9710-x.

Buchari, A. (2018). Peran Guru Dalam Pengelolaan Pembelajaran. *Jurnal Ilmiah Iqra'*, *12*(2), 106. https://doi.org/10.30984/jii.v12i2.897.

Bürgener, L., & Barth, M. (2018). Sustainability competencies in teacher education: Making teacher education count in everyday school practice. *Journal of Cleaner Production*, *174*, 821–826. https://doi.org/10.1016/j.jclepro.2017.10.263.

Carrier, S. J. (2013). Elementary Preservice Teachers' Science Vocabulary: Knowledge and Application. *Journal of Science Teacher Education*, *24*(2), 405–425. https://doi.org/10.1007/s10972-012-9270-7.

Chen, J. L., & Mensah, F. M. (2018). Teaching Contexts That Influence Elementary Preservice Teachers' Teacher and Science Teacher Identity Development. *Journal of Science Teacher Education*, *29*(5), 420–439. https://doi.org/10.1080/1046560X.2018.1469187.

Cofré, H., González-Weil, C., Vergara, C., Santibáñez, D., Ahumada, G., Furman, M., Podesta, M. E., Camacho, J., Gallego, R., & Pérez, R. (2015). Science Teacher Education in South America: The Case of Argentina, Colombia and Chile. *Journal of Science Teacher Education*, *26*(1), 45–63. https://doi.org/10.1007/s10972-015-9420-9.

Darmadi, H. (2016). Tugas, peran, kompetensi, dan tanggung jawab menjadi guru profesional. *Edukasi: Jurnal Pendidikan*, *13*(2), 161–174. https://doi.org/10.31571/edukasi.v13i2.113.

Desstya, A., Prasetyo, Z. K., Suyanta, Susila, I., & Irwanto. (2019). Developing an instrument to detect science misconception of an elementary school teacher. *International Journal of Instruction*, *12*(3), 201–218. https://doi.org/10.29333/iji.2019.12313a.

Diamond, B. S., Maerten-Rivera, J. L., Rohrer, R., & Lee, O. (2013). Elementary Teachers ' Science Content Knowledge : Relationships Among Multiple Measures. *Florida Journal of Educational Research*, *51*(January 2013), 1–20.

Fauth, B., Decristan, J., Decker, A. T., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. *Teaching and Teacher Education*, *86*, 102882. https://doi.org/10.1016/j.tate.2019.102882.

Firestone, A. R., Cruz, R. A., & Rodl, J. E. (2020). Teacher Study Groups: An Integrative Literature Synthesis. *Review of Educational Research*, *90*(5), 675–709. https://doi.org/10.3102/0034654320938128.

Fragkiadaki, G., Fleer, M., & Ravanis, K. (2019). A Cultural-Historical Study of the Development of Children's Scientific Thinking about Clouds in Everyday Life. *Research in Science Education*, *49*(6), 1523–1545. https://doi.org/10.1007/s11165-017-9665-8.

Großschedl, J., Mahler, D., Kleickmann, T., & Harms, U. (2014). Content-Related Knowledge of Biology Teachers from Secondary Schools: Structure and learning opportunities. *International Journal of Science Education*, *36*(14), 2335–2366. https://doi.org/10.1080/09500693.2014.923949.

Hanifah, H. (2018). Penerapan Manajemen Program Pembelajaran Bagi Guru Paud Dalam Meningkatkan Kinerja Pendidik. *Comm-Edu (Community Education Journal)*, *1*(3), 24. https://doi.org/10.22460/comm-edu.v1i3.1102.

Harrell, P., & Subramaniam, K. (2015). Elementary pre-service teachers' conceptual understanding of dissolving: a Vygotskian concept development perspective. *Research in Science and Technological Education*, *33*(3), 304–324. https://doi.org/10.1080/02635143.2015.1027188.

Hartanti, A. S., & Yuniarsih, T. (2018). Pengaruh Kompetensi Profesional Guru Dan Motivasi Kerja Terhadap Kinerja Guru Di Sekolah Menengah Kejuruan. *Jurnal Pendidikan Manajemen Perkantoran*, *3*(1), 167. https://doi.org/10.17509/jpm.v3i1.9452.

Hasfira, H., & Marelda, M. (2021). Peran Guru Dalam memotivasi Siswa Pada Masa Pandemi. *Jurnal Pendidikan Dan Konseling (JPDK)*, *3*(1), 80–84. https://doi.org/10.31004/jpdk.v3i1.1430.

Hilpert, J. C., & Marchand, G. C. (2018). Complex Systems Research in Educational Psychology: Aligning Theory and Method. *Educational Psychologist*, *53*(3), 185–202. https://doi.org/10.1080/00461520.2018.1469411.

Jalil, M. (2016). Pengembangan Pembelajaran Model Discovery Learning Berbantuan Tips Powerpoint Interaktif Pada Materi Interaksi Makhluk Hidup Dengan Lingkungan. *Refleksi Edukatika : Jurnal Ilmiah Kependidikan*, *6*(2). https://doi.org/10.24176/re.v6i2.604.

Khoirudin, M. (2016). Pengembangan Modul Pembelajaran Ipa Biologi Berbasis Inkuiri Pada Materi Interaksi Antar Makhluk Hidup Dengan Lingkungannya. *BIOEDUKASI (Jurnal Pendidikan Biologi)*, *7*(2). https://doi.org/10.24127/bioedukasi.v7i2.611.

Kind, V. (2019). Development of evidence-based, student-learning-oriented rubrics for pre-service science teachers' pedagogical content knowledge. *International Journal of Science Education*, *41*(7), 911–943. https://doi.org/10.1080/09500693.2017.1311049.

Kural, M., & Kocakülah, M. S. (2016). Teaching for Hot Conceptual Change: Towards A New Model, Beyond the Cold And Warm Ones. *European Journal of Education Studies*, *2*(8), 1–40. https://doi.org/10.5281/zenodo.163535.

Lazarides, R., Fauth, B., Gaspard, H., & Göllner, R. (2021). Teacher self-efficacy and enthusiasm: Relations to changes in student-perceived teaching quality at the beginning of secondary education. *Learning and Instruction*, *73*(February 2019). https://doi.org/10.1016/j.learninstruc.2020.101435.

Lee, O., Llosa, L., Jiang, F., Haas, A., O'Connor, C., & Van Booven, C. D. (2016). Elementary teachers' science knowledge and instructional practices: Impact of an intervention focused on english language learners. *Journal of Research in Science Teaching*, *53*(4), 579–597. https://doi.org/10.1002/tea.21314.

Lee, T. D., & Gail Jones, M. (2018). Elementary Teachers' Selection and Use of Visual Models. *Journal of Science Education and Technology*, *27*(1), 1–29. https://doi.org/10.1007/s10956-017-9705-1.

Lewis, A. D. (2019). Practice what you teach: How experiencing elementary school science teaching practices helps prepare teacher candidates. *Teaching and Teacher Education*, *86*, 102886. https://doi.org/10.1016/j.tate.2019.102886.

Lohbeck, A., Hagenauer, G., & Frenzel, A. C. (2018). Teachers' self-concepts and emotions: Conceptualization and relations. *Teaching and Teacher Education*, *70*, 111–120. https://doi.org/10.1016/j.tate.2017.11.001.

Luik, P., Taimalu, M., & Suviste, R. (2018). Perceptions of technological, pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia. *Education and Information Technologies*, *23*(2), 741–755. https://doi.org/10.1007/s10639-017-9633-y.

Montolalu, C., & Langi, Y. (2018). Pengaruh Pelatihan Dasar Komputer dan Teknologi Informasi bagi Guru-Guru dengan Uji-T Berpasangan (Paired Sample T-Test). *D'CARTESIAN*, *7*(1), 44. https://doi.org/10.35799/dc.7.1.2018.20113.

Mulyana. (2017). Kompetensi Guru Pendidikan Jasmani Sekolah Dasar. *Parameter: Jurnal Pendidikan* , *29*(1), 39–45. https://doi.org/10.21009/parameter.291.05.

Mutakinati, L., Anwari, I., & Yoshisuke, K. (2018). Analysis of students' critical thinking skill of middle school through stem education project-based learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54–65. https://doi.org/10.15294/jpii.v7i1.10495.

Nilsson, P., & Karlsson, G. (2019). Capturing student teachers' pedagogical content knowledge (PCK) using CoRes and digital technology. *International Journal of Science Education*, *41*(4), 419–447. https://doi.org/10.1080/09500693.2018.1551642.

Nixon, R. S., Smith, L. K., & Sudweeks, R. R. (2019). Elementary teachers' science subject matter knowledge across the teacher career cycle. *Journal of Research in Science Teaching*, *56*(6), 707–731. https://doi.org/10.1002/tea.21524.

Norris, C. M., Morris, J. E., & Lummis, G. W. (2018). Preservice teachers' self-efficacy to teach primary science based on 'science learner' typology. *International Journal of Science Education*, *40*(18), 2292–2308. https://doi.org/10.1080/09500693.2018.1528645.

Papageorgiou, G., Stamovlasis, D., & Johnson, P. (2013). Primary Teachers' Understanding of Four Chemical Phenomena: Effect of an In-Service Training Course. *Journal of Science Teacher Education*, *24*(4), 763–787. https://doi.org/10.1007/s10972-012-9295-y.

Paulick, I., Großschedl, J., Harms, U., & Möller, J. (2016). Preservice Teachers' Professional Knowledge and Its Relation to Academic Self-Concept. *Journal of Teacher Education*, *67*(3), 173–182. https://doi.org/10.1177/0022487116639263.

Pope, D. (2019). Subject knowledge for primary teaching: the influence of the personal dimension on beginning primary teachers' conceptualisations and interpretations. *Education 3-13*, *47*(3), 293–307. https://doi.org/10.1080/03004279.2018.1437199.

Ríordáin, M. N., Paolucci, C., & Lyons, T. (2019). Teacher Professional Competence: What Can Be Learned About the Knowledge and Practices Needed for Teaching? *Examining the Phenomenon of "Teaching Out-of-Field*, 129–149. https://doi.org/10.1007/978-981-13-3366-8.

Risnani, L. Y. (2019). Teknik SCAMPER : Stimulasi Kreativitas Mahasiswa Calon Guru Biologi pada Aktivitas Laboratorium SCAMPER. *Jurnal Pendidikan Biologi*, *12*(1), 35–40. https://doi.org/10.20961/bioedukasi-uns.v12i1.27396.

Rollnick, M. (2017). Learning About Semi Conductors for Teaching—the Role Played by Content Knowledge in Pedagogical Content Knowledge (PCK) Development. *Research in Science Education*, *47*(4), 833–868. https://doi.org/10.1007/s11165-016-9530-1.

Salmia, & Yusri, M. (2021). Peran Guru dalam Pembelajaran Abad 21 di Masa Pandemik Covid-19. *Indonesian Journal of Primary Education*, *5*(1), 82–92. https://doi.org/10.17509/ijpe.v5i1.31955.

Schultz, M., Lawrie, G. A., Bailey, C. H., Bedford, S. B., Dargaville, T. R., O'Brien, G., Tasker, R., Thompson, C. D., Williams, M., & Wright, A. H. (2017). Evaluation of diagnostic tools that tertiary teachers can apply to profile their students' conceptions. *International Journal of Science Education*, *39*(5), 565–586. https://doi.org/10.1080/09500693.2017.1296980.

Subramaniam, K. (2019). An exploratory study of student teachers' conceptions of teaching life science outdoors. *Journal of Biological Education*, *53*(4), 399–411. https://doi.org/10.1080/00219266.2018.1472133.

Sugihartini, N. M., Agung, A. A. G., & Dantes, K. R. (2018). Kontribusi Implementasi Menejemen Sekolah Berbasis Nilai-Nilai Kearifan Lokal Tri Hita Karana, Kepemimpinan Pelayan Kepala Sekolah dan Kepuasan Kerja Terhadap Komitmen Organisasional Guru di SMP Negeri Kota Singaraja Buleleng. *Jurnal Administrasi Pendidikan Indonesia*, *9*(2), 111–120. https://doi.org/10.23887/japi.v9i2.2776.

Suprihatin, S. (2015). Upaya Guru Dalam Meningakatkan Motivasi Belajar Siswa. *PROMOSI (Jurnal Pendidikan Ekonomi)*, *3*(1), 73–82. https://doi.org/10.24127/ja.v3i1.144.

Taştan, S. B., Davoudi, S. M. M., Masalimova, A. R., Bersanov, A. S., Kurbanov, R. A., Boiarchuk, A. V., & Pavlushin, A. A. (2018). The impacts of teacher's efficacy and motivation on student's academic achievement in science education among secondary and high school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(6), 2353–2366. https://doi.org/10.29333/ejmste/89579.

Trygstad, P. J., Smith, P. S., Banilower, E. R., & Nelson, M. M. (2013). The Status of Elementary Science Education: Are We Ready for the Next Generation Science Standards? *Retreived November*, *18*(April), 2013.

Verdugo, J. J., Solaz-Portolés, J. J., & Sanjosé, V. (2016). Pre-service primary school teachers' science content knowledge: An instrument for its assessment. *International Journal of Innovation in Science and Mathematics Education*, *24*(2), 37–51.

Wahyono, P., Husamah, H., & Budi, A. S. (2020). Guru profesional di masa pandemi COVID-19: Review implementasi, tantangan, dan solusi pembelajaran daring. *Jurnal Pendidikan Profesi Guru*, *1*(1), 51–65. https://doi.org/10.22219/jppg.v1i1.12462.

Wahyuni, E. S., & Yokhebed. (2019). Deskripsi Media Pembelajaran Yang Digunakan Guru Biologi Sma Negeri Di Kota Pontianak. *Jurnal Pendidikan Informatika Dan Sains*, *8*(1), 32. https://doi.org/10.31571/saintek.v8i1.1105.

Widodo, A., Rochintaniawati, D., & Riandi. (2017). Primary School Teachers' Understanding of Essential Science Concepts. *Cakrawala Pendidikan*, *3*(XXXVI), 522–528. https://doi.org/10.21831/cp.v36i3.11921.

Wulandari, T. A. J., Sibuea, A. M., & Siagian, S. (2019). Pengembangan Media Pembelajaran Berbasis Multimedia Interaktif Pada Mata Pelajaran Biologi. *Jurnal Teknologi Informasi & Komunikasi Dalam Pendidikan*, *5*(1), 75–86. https://doi.org/10.24114/jtikp.v5i1.12524.

Zapko, K. A., Ferranto, M. L. G., Blasiman, R., & Shelestak, D. (2018). Evaluating best educational practices, student satisfaction, and self-confidence in simulation: A descriptive study. *Nurse Education Today*, *60*, 28–34. https://doi.org/10.1016/j.nedt.2017.09.006.