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

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A B S T R A C T

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 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...
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 & Yuniarsh, 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; Riordán 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; Desstyta 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; Paullick 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; Desstyta 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 & Nurcahya, 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 (forty) 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>
<thead>
<tr>
<th>Table 1. Concepts and dissemination of biology questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
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<tr>
<td>1</td>
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</tbody>
</table>

Rif'at Shafwatul Anam / Science Content Knowledge of Pre-Service Teachers in Biology Elementary School Level
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

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

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

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


