PRIMARY SCHOOL TEACHERS' UNDERSTANDING OF ESSENTIAL SCIENCE CONCEPTS

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Abstract: Teacher's understanding of science is a prerequisite for teaching science. Due to the lack of science background during their studies, some primary school teachers have limited understanding of science. This study aims at identifying primary school teacher's understanding of essential science concepts. Data were collected from 293 participants of workshops of professional certification program at university. Teacher's understanding was measured using a multiple choice test whose answers are in the form of degree of certainty. The study finds that many teachers do not have good understanding of science. Misconceptions are also identified in a number of areas. Student textbooks, myths spread over in the communities, and narrow interpretation of religious teaching are some sources of teacher's misconceptions. These findings suggest that future professional development program for primary school teachers should be designed in the areas of subject matters and subject matter pedagogy.

Keywords: elementary school teachers, misconception, science, understanding

PEMAHAMAN GURU SEKOLAH DASAR TERHADAP KONSEP DASAR IPA

Abstrak: Pemahaman guru tentang sains adalah prasyarat untuk mengajarkan sains. Karena kurangnya latar belakang sains selama studi mereka, beberapa guru sekolah dasar memiliki pemahaman sains yang terbatas. Penelitian ini bertujuan untuk mengidentifikasi pemahaman guru sekolah dasar tentang konsep sains penting. Data dikumpulkan dari 293 peserta lokakarya program sertifikasi profesional di universitas. Pemahaman guru diukur dengan menggunakan tes pilihan ganda yang jawabannya berupa tingkat kepastian. Studi ini menemukan bahwa banyak guru tidak memiliki pemahaman sains yang baik. Kesalahpahaman juga teridentifikasi di sejumlah daerah. Buku teks pelajar, mitos tersebar di masyarakat, dan interpretasi sempit ajaran agama adalah beberapa sumber kesalahpahaman guru. Temuan ini menunjukkan bahwa program pengembangan profesional masa depan untuk guru sekolah dasar harus dirancang di bidang materi pelajaran dan materi pelajaran pedagogi.

Kata Kunci: guru sekolah dasar, kesalahpahaman, sains, pengertian

INTRODUCTION

Results of international comparative studies on students' achievement in science (Martin, et al., 2012; OECD, 2014) suggest that there is an urgent need to improve the quality of education in Indonesia. One of the massive efforts run by the government is teacher certification, a

program to improve teacher quality. Teacher certification program requires teachers to obtain a teaching certificate (Jalal et al., 2009; Republik Indonesia, 2005). Teacher certification program was designed to improve the quality of the teachers by attracting better teacher candidates, uplifting the competencies of the existing teachers, and improving the commitment of the teachers (Chang et al., 2014). As by the law certified teachers are given special allowance that doubles their income, teacher certification program increased the interest to be teachers and improve teachers' academic qualifications. Studies on the impact of the certification program, however, reported that the program brought little impact on the improvement of teachers' teaching practice (Chang et al., 2014).

One of key factors that determine teachers' teaching is their understanding of the content (Ball, Thames, & Phelps, 2008; Harlen, 1997). As stated in the Teachers and Lecturers Law (Republik Indonesia, 2005) understanding of content is one of four essential competencies for teachers. A teacher who does not have a good understanding of the content will not be able to deliver quality lessons (Daehler & Shinohara, 2001; Parker & Heywood, 2000; Rollnick, 2016). As part of the training for the obtainment of teacher certificate (popularly called Pendidikan dan Latihan Profesi Guru or PLPG) participants are received a session on content subject matter. Since primary school teachers are classroom teachers and they have to teach a number of subjects, the content of the training covers all of those subjects. As a consequence, science is only given a small portion in the training.

The issue of primary school understanding of science is very complicated not only because they have to teach many subjects but also because of the variety of the teachers' education background. Indeed, the law prescribes teachers to have Sarjana Degree (four years education at the university) but the law also allow graduates of non-primary school teacher education (popularly called Pendidikan Guru Sekolah Dasar or PGSD) to be primary school teachers. Due to this "relatively open" recruitment system some primary school teachers do not have sufficient knowledge background in science. At the worst scenario, a primary school teacher may only learn science in the school (until year 10).

Indeed, there is no standard formula of minimum science requirement for primary school teachers, however, teachers at least need to have a good understanding of the basic concepts they are expected to teach (Appleton, 1995; Atwood, et al., 2010; Harlen, 1997; Krall, Lott, & Wymer, 2009). A number of studies reported that teacher' understanding of the content affect students' learning (Hill, Rowan, & Ball, 2005; Sadler, et al., 2013).

As documented by a number of studies, some teachers hold similar understanding with their students (Kerr, Beggs, & Murphy, 2006; Patrick & Tunnicliffe, 2010). Other studies (Kallery & Psillos, 2001; Tekkaya, Cakiroglu, & Ozkan, 2004) even documented misconception amongst primary school teachers. Teachers who hold misconception are not only unable to facilitate students' learning but they

will pass their misconception to their students.

Lack of understanding of content influence teachers Pedagogical Content Knowledge (PCK) since teacher have difficulties to blend their pedagogical knowledge and content knowledge (Appleton, 2008; Rollnick, 2016). Even when teacher have good pedagogical knowledge, they will not be able to develop effective teaching strategies for delivering the content (Parker & Heywood, 2000). As a result, teachers may base their teaching on their experience or imitating their teachers (Kerr et al., 2006). In addition, lack of understanding of content may also influence teachers' confidence to teach the content (Harlen, 1997; Tekkaya et al., 2004).

The lack of science knowledge background forced primary school teachers to rely on other sources for understanding science phenomena, such as common sense, everyday life practices, or books. Unfortunately, such strategy is not without a risk since those resources may present the science concepts inaccurately or the interpretation is inaccurate. As suggested by Mansour (2010), people interpretation of natural phenomena are influenced by their beliefs, including their religious beliefs.

Basically there are four main areas of science addressed in the primary school curriculum, namely living things and life processes, properties of matter, energy, and earth and space sciences (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2016; Kementerian Pendidikan Nasional, 2006). The first area covers nearly 45% of the science content while the other three areas are equally distributed.

The main aim of this study is to identify primary school teachers' understanding of essentials science concepts taught at primary school. The research questions addressed are as follow: (1) How is the level primary school teachers' understanding of essentials science concepts?; (2) Is there particular area of science that present difficulties to teachers?

METHOD

This study is a descriptive study using a survey method. Data were collected from 293 primary school teachers who participated in a ten-day professional certification program (PLPG) organized at Universitas Pendidikan Indonesia. All teachers are experienced teachers with at least five years teaching experience.

Teachers' understanding was assessed using a 20-item multiple choice test developed based on the four areas of science as prescribed in the school curriculum. The test also required teachers to write teachers' certainty of their answers. The items are mainly drawn from issues or phenomena commonly found in daily life. For example, the teachers are asked about the nutrient in an egg.

- Which part of an egg has more protein?
  A. White part
  B. Yellow part (yolk)
  C. There is no difference

  How convince are you with your answer?
  a. Strongly convince
  b. convince
  c. Not convince
  d. Not convince at all

After completing the test, some teachers were sampled for an interview. The interviews were conducted to explore further their understanding and their reasoning for the answers. The interviews were also designed to identify sources of teachers' misconceptions.

Responses of the respondents are analysed based on a framework developed by Hasan, Bagayoko and Kelley (1999) who classified an understanding into "understand" (correct answer + convince/strongly convince), "do not understand" (correct/incorrect answer + not convince/not convince at all) and "misconception" (incorrect answer + convince/strongly convince). Descriptive analyses were conducted to draw general feature of teachers' understanding as well as more detailed feature for each area and gender.

RESULTS AND DISCUSSION

Result

The analysis showed that the level of elementary teachers' understanding about essential science concepts is fairly low (Table 1). The results also revealed that 87% of the teachers scored only 50 or lower. This finding is almost similar to the results of previous studies (Balfakih, 2002; Papageorgiou, Stamovlasis, & Johnson, 2013).

Analysis of the confidence level of the teachers (Hasan et al., 1999) showed that only one third of teachers who were really understand the contents, while the rest of the teacher either did not understand and hold misconception (Figure 1).

Table 1. The Profile of Primary School Teachers Understanding of Science Concepts

No.	Parameter	Score
1.	Average	41,7
2.	Standard Deviation	9,7
3.	Minimum score	20
4.	Maximum Score	70
5.	Number of participants with score ≤ 50	255 teacher
6	Number of participants with score > 50	38 teacher

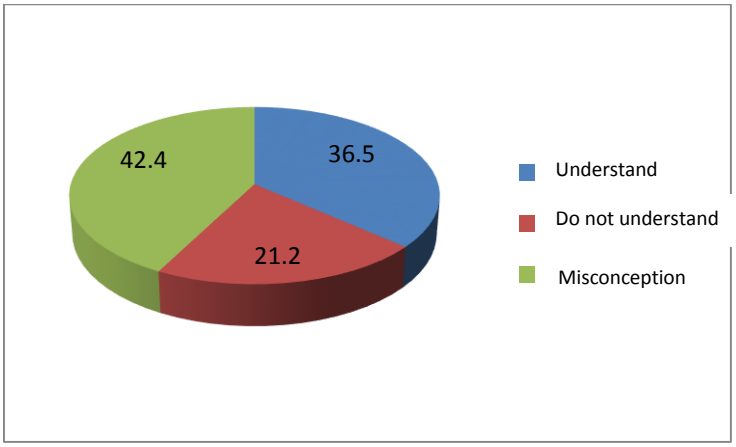

Figure 1. Percentage of Teachers' Understanding of Science Concepts

More detailed analysis related to teachers' understanding to the four essential concepts showed that only 36% of the teachers really understand science concepts (Table 2). In three areas (living things and life processes, energy, and earth and space sciences) the teachers scored lower than 40. Those three concepts belong to abstract concepts which are difficult to be observed (White, 1994).

Table 2. Teachers Understanding of Four Science Areas

No.	Group of content	Understand	Do not understand	Misconception
1.	Living things and life processes	25.5	**18.0**	56.5
2.	Properties of matter	48.5	20.9	30.7
3.	Energy	35.0	13.7	51.3
4.	Earth and space science	36.8	32.0	31.2
	Average	36.5	21.2	42.4

The concepts of "Living things and life processes" and "Properties of matter" give the highest misconception (more that 50% teacher hold misconception in these two areas). One of the questions asked related to "Living things and life processes" was the function of blood: "Which part of blood that transports food nutrient in human body?" Most of the teachers answered that food nutrient was transported by red blood cells. This answer is incorrect because as the main function of red blood cells is to transport gases (mainly oxygen and carbon dioxide), while food nutrient is dissolved and transported by blood plasm.

Related to the topic of energy, one of the questions was: "In the room temperature, what material is best to keep ice from melting?" Most of respondents chose aluminium foil as the best material, instead of thick wool. They thought that thick wool will make the ice melts very quickly. They use an analogy that wool can keep the body warm in cold weather. They did not understand that the body is warm because the wool insulates heat released by the body and keeps it inside the blanket that makes us warm.

Gender analysis shows that there is no difference understanding between male and female teachers (Table 3). These results indicate that the low mastery of science concepts is a common phenomenon, both among female and male teachers. Moreover, this study challenges the common belief that male have higher interest and achievement in physical sciences compare to female (Hoffman, 2002). A possible explanation for the finding in this study is that female worked extra hard to understand science disregard they like it or not (Larson, et al., 2014) as it is common in Indonesian culture that female try to accept and meet the expectation of the society.

Table 3. Average Scores of Male and Female Teachers

No.	Group of content	Male	Female
1.	Living things and life processes	33	32
2.	Properties of matter	53	52
3.	Energy	44	44
4.	Earth and space science	54	56
	Average	46	46

A more detailed analysis of the proportion for each category of understanding (understand, do not understand, and misconception) shows that male teachers tend to be more undecided than their colleague female teachers (Figure 2). As shown in the figure, female teachers tend to be sure with their answers disregard whether or not the answers were correct.

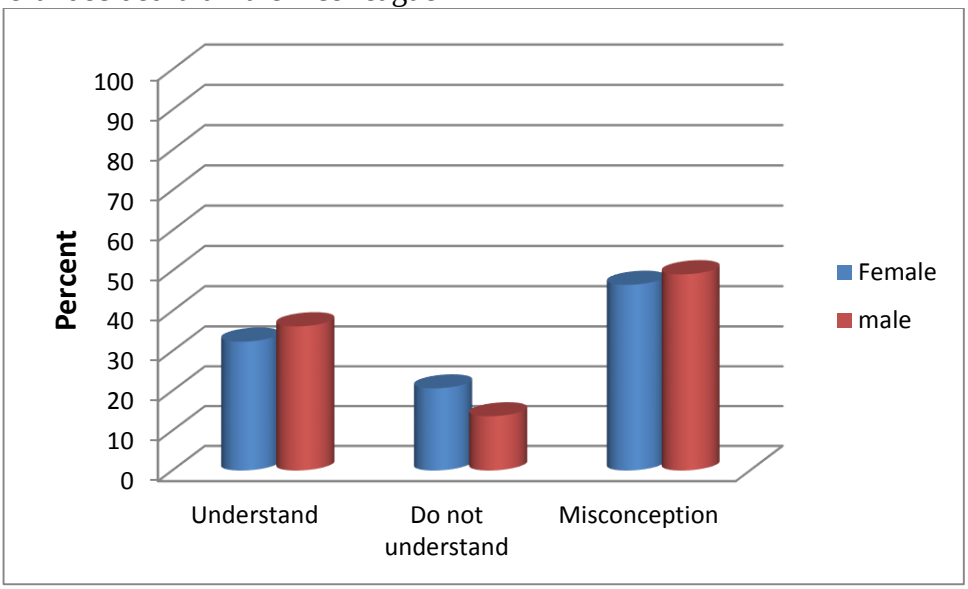

Figure 2. Proportion of Female and Male Teachers for Each Category of Understanding

The results that there is no difference between male and female teachers' understanding (Table 3) and that female teachers tend to have more firmed answers (Figure 2) presents a contradiction with the common beliefs that females do not like science and that females tend to be undecided. This finding clearly challenges the mainstream belief about gender preferences in science and the need for feminist science education (Shah, 2012).

Discussion

In general, the results of this study are consistent with previous studies that elementary school teachers' understanding of science is low (Atwood et al., 2010; Balfakih, 2002; Bulunuz & Jarret, 2010; Krall et al., 2009). In addition, the study also finds that some teachers, like their students, also hold misconceptions (Papageorgiou et al., 2013). As respondents of this study

are experienced teachers, it seems that increasing age and experience give little impact on the improvement of teachers' understanding (Großschedl, et al., 2014). The popular idiom in Indonesia that experience is the best teacher does not always apply to the teachers. Clearly there is a need for system that can facilitate teachers to learn from their experience.

We identify a number of sources that contribute to teachers' misconception, among other things are: text books, cultural practices in the society, and limited interpretation of the religious teaching. Although textbooks have been reviewed in many stages; however we still find some misconceptions in some books. In one of the student textbook published by the government we noted exactly the same misconception on the function of red blood cells: "Pada jonjot terdapat pembuluh darah. Setelah diserap, sari makanan akan diangkut oleh sel darah merah dan diedarkan ke seluruh sel tubuh melalui pembuluh darah" (Widodo, et al., 2009, p. 45). The book clearly says that food nutrients are transported by red blood cells, instead of blood plasm.

Cultural habits exist in society are also one of the factors that leads to misconceptions (Papageorgiou et al., 2013). A common example in Indonesia is the habit of people to take egg yolk (the yellow part of the egg) because it is believed that the yolk can make children grow better and adults become stronger. Because eggs are often associated with a good source of protein, many people think that the egg yolk is a source of protein, while the yolk is actually mostly fat.

Limited interpretation of religious teaching can also become a source of misconceptions. Many teachers believe that the number of ribs male is fewer than those of female because they believe that women are created from the rib of Adam, which mean that Adam and all male have fewer ribs than Eve and other females. This understanding is of course incorrect because the number of ribs of men and women is similar. This result is consistent with Mansour's statement (2010) that in religious communities, religious teachings can affect people understanding of the natural phenomena.

The fact that teachers' understanding of science concepts is fairly low suggests that there is an urgent need to improve teachers' content knowledge. Since primary education plays very important roles in building foundations for the next education levels, the issue of upgrading teachers' content knowledge is very critical. We suspect that one of the factors that make our students do not perform well in science (Martin et al., 2012; OECD, 2014) is the lack of solid science foundation in the primary education. In the workshop for the obtainment of teacher certificate (PLPG) for primary school teachers, it is allocated 30 hours for content (mathematics, science, Bahasa Indonesia, social studies, and civics education). As a result, science is allocated with 6 hours of training that certainly not enough to upgrade teachers' understanding of the science concepts.

Explaining teachers about the science concepts is certainly necessary to improve teachers' understanding of science concepts.

Improvement of teachers' understanding, however, does not necessarily mean that it will improve teachers' competencies to teach science. A good training should lead to the improvement of teachers' knowledge to teach science effectively. Therefore, the training should focus more on developing teachers' PCK instead of content knowledge or pedagogical knowledge separately (Ball et al., 2008; Rollnick, 2016). The thinking paradigm that divides teacher competencies into pedagogical competencies and content competencies (Republik Indonesia, 2005) can lead to the ignorance of PCK as an integration of pedagogical and content knowledge. PCK is not just a mix of content knowledge and pedagogical knowledge, instead it is a new specific knowledge developed as an amalgam of content knowledge and pedagogical knowledge (Loughran, Berry, & Mulhall, 2012; Shulman, 1987).

Based on the finding of the study, we suggest that programs to improve the competence of teachers should be oriented toward the improvement of teachers' PCK rather than simply on separate content and pedagogy. Previous studies on PCK reveal that PCK-based professional development can improve the ability of teachers (Driel & Berry, 2012; Driel, De Jong, & Verloop, 2002; Park, Jang, & Chen, 2011). We argue that the problem faced by primary school teachers in implementing the new curriculum (Kurikulum 2013) is not just rooted at the lack of teachers' competencies on making teaching media, understanding the new curriculum, relating subjects into a theme, and using technology (Krissandi & Rusmawan, 2015) but more importantly their lack of PCK. To facilitate the development of their PCK, teachers need feedback from peers and supervisors (Anwar, et al., 2016). For this reason, teacher professional development should include session on discussing teachers teaching practice and facilitate them to reflect on their practices.

CONCLUSION

This study shows that primary school teachers' understanding of essential science concepts was low (41.7). Only 36.5% of the teachers really mastered the concepts, while the remaining of the teachers either do not understand (21.2%) or hold misconceptions (42.4%). The content least understood by the teachers are "Living organisms and life processes" and "Energy". The two areas consists of processes and abstract concepts that relatively difficult. Gender analysis shows that there is no difference in the level of understanding between male and female teachers.

Because the mastery of science concepts affect the ability of a teacher to teach science, this study suggests the need of more systematic programs to improve teachers' competencies to teach science. Teacher professional development programs should not present content and pedagogy as two separate contents; rather they should address them as an integrated knowledge of pedagogical content knowledge.

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