ARE OUR SCIENCE TEACHERS SCIENTIFICALLY LITERATE? AN INVESTIGATION OF SCIENCE TEACHERS' LEVEL OF SCIENTIFIC LITERACY IN CAGAYAN DE ORO CITY, PHILIPPINES

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ABSTRACT: The main goal of science education is to produce a scientifically literate community. Science teachers are the key to achieving scientifically literate citizenry because of their essential role in education at all levels. It is for this reason that science teachers themselves must be scientifically literate to be able to prepare students adequately. This study examined the levels of scientific literacy (SL) of randomly selected public elementary and high school science teachers of Cagayan de Oro City (n=92 and n=88 respectively), using a descriptive survey. A standardized test was utilized to determine the scientific literacy (SL) in areas like Nature of Science (NOS), Science, Technology, and Society (STS), Physical Science (PS), Earth and Space Science (ESS), Life Science (LS), and Health Science (HS). Analysis of results indicated that the respondents possess a satisfactory SL, with the highest score in Earth and Space Science (ESS) component while lowest in Physical Sciences (PS). Differences in SL levels were also noted between elementary and high school science teachers. It is recommended that in the design of both science teacher education curriculum and professional development training for in-service teachers, least mastered concepts in science must be given attention. Similarly, ample opportunities should also be given to preservice and in-service teachers to develop high levels of scientific literacy.

Keywords: Knowledge, Literacy, Professional Development, Science Teaching, Training

1. INTRODUCTION

Science, in the new K to 12 Curriculum for Basic Education in the Philippines, is taught using the spiraling approach, which emphasizes ordering topics from the simplest to the most complex rather than by arranging them in a logical sense. In this setup, teachers are expected to be experts in all sciences (earth and space science, biology, chemistry, and physics) since all of these are taught in all grade levels with increasing complexity. This presents a problem when teachers teaching science subject lacks content expertise, which would prevent them from teaching effectively. Teachers lacking a good foundation on content may find it challenging to teach concepts unfamiliar to them and only teach those concepts they are familiar with. This kind of practice ultimately affects the ability of our learners to fully understand the nature of science and its application to our day-to-day lives. This entails that teachers must be scientifically literate first before they can teach science.

Scientific literacy refers to the understanding of science that allows a person to participate in socio-scientific topics actively and to make informed and sound decisions on these issues, as well as the appreciation of processes, values, and ethics related to science [1]. Having an enriched, scientifically literate society is vital because every public issue requires some scientific background. People encounter science and its laws from the moment they wake up to the moment they go to sleep. That is why citizens must have some level of scientific literacy [2].

The main goal of science education is to have a scientifically literate community [3]–[5]. Science teachers are the key to the achievement of scientific literacy at all levels of education since they have an essential role in preparing scientifically literate citizenry [4]. One way to achieve this is to strengthen the subject content knowledge of teachers since many global educators highlighted the importance of the subject expertise of teachers in the effective education system [6]. It is even accepted a long

time ago that good teacher subject knowledge helps improve the literacy of the students [7]. Furthermore, it is in elementary school science where the foundation is laid for future advanced science learning. Still, it is with great sadness to note that primary school teachers are often unprepared to set students on the path to higher-level success in science and allied fields [8].

The data for Cagayan de Oro City, Philippines, revealed alarming findings of the scientific literacy of elementary students, as shown in the Grade 6 National Achievement Test (NAT) Results from 2010 to 2015. Although there is a steady increase since 2010, the mean percentage score for science subjects is still below the target of the Department of Education, which is at least 75%. The National Achievement Test though, does not measure the scientific literacy of students, but it does represent the minimum competency required of a specific grade level. Thus, the NAT results in one way or another represent the competencies mastered by students. These results give us an idea of the quality of science education, the Division of Cagayan de Oro has. As shown in Figure 1, the teaching grade level was used to determine the differences in their levels of scientific literacy. Thus, this study aims to determine the levels of scientific literacy of elementary and high school science teachers in teaching in public schools under the Department of Education, Division of Cagayan de Oro City.



Figure 1. Schematic representation of the variables considered in the study

2. MATERIALS AND METHODS

This study utilized a descriptive survey research design [9]. The main goal of this study is to determine the levels of

scientific literacy of elementary and high school science teachers. Data collection took place in the respective schools of the participants. Ample time was given to the respondents to assure the reliability and validity of results. Data encoding and analyses took place at the University of Science and Technology of Southern Philippines. In this study, 100 elementary (Grade 3 to 6) and 100 high school (Grade 7 to 10) teachers were considered as the sample. Incomplete questionnaires were considered as mortality and were no longer included in the analysis of data. A total of 92 teachers for elementary and 88 teachers for high school was considered as the sample after a quality check of their respective questionnaires.

The scientific literacy was determined using an instrument "Test for Basic Scientific Literacy" (TBSL) developed by Laugksch & Spargo (1996). This instrument measures scientific literacy in terms of science content, nature of science, and science and technology and society. The science content covers earth and space science, physical science, life science, and health science. This test was considered in this study due to its wide use in different contexts and cultures, as shown in the literature. The research instrument was reviewed in terms of its content and face validity with the help of experts in chemistry, biology, and physics education from a nearby university. They were given ample time to review the instrument. The instrument was then revised based on the comments and suggestions of the content experts. The revised instrument was then pilot-tested to 45 elementary science teachers from the Division of Cagayan de Oro. The answers were then tabulated and analyzed using an Item Analysis software to check for its reliability. The TBSL instrument was also subjected to internal consistency reliability using Cronbach's alpha with a value of 0.83.

The data collected for this study was quantitatively analyzed. The TBSL instrument is a true-false type of test, which was scored by assigning a score of 1 for a correct response while a score of zero for an incorrect answer. For the TBSL, the respondents are expected to obtain 68 out of 110 items (62%) [10].

Participation in the study was voluntary, and the highest priority was given to ensure the confidentiality and anonymity of all questionnaires and responses of all participants. Necessary measures were also taken into account to ensure that the participants were not harmed in any way. Study objectives were clearly explained to all participants prior to the data collection [11]. The method, as well as the research instrument utilized in this study, were thoroughly reviewed for ethical considerations by the university research office through our research program officers and external reviewers.

3. FINDINGS

Profile of Elementary Science Teachers

The profile of the elementary science teachers who served as respondents (n=92) for this research is summarized in Table 1. The majority of the respondents are between the ages of 25-44 years old, female, married, and teaching Grade 4 and 6 levels with less than five years of teaching experience. The profile of high school science teachers (n=88) for this research is also summarized in Table 1. The majority are between the ages of 25-44 years old, female, married, and teaching Grade 8 and 9 levels with less than five years. Respondents are mostly in the entry position/rank, which is Teacher 1.

Levels of Scientific Literacy

The levels of scientific literacy of both elementary and high school science teachers are presented in Table 2. As shown, both primary and high school science teachers scored lowest in the Physical Science component while highest in Earth and Space Science part. No significant differences were also noted in the Nature of Science, Science, Technology, and Society, and Physical Science components, while significant differences in scores were noted in Earth and Space Science, Life Science, and Health Science. In terms of the overall scientific literacy, a significant difference in scores was noted.

Table 1. The Science Teachers' Profile of the Division of Cagayan

Parameter	Elementary (n=92)		High School (n=88)					
-	f	%	f	%				
Age (years)								
55 and above	4	4.34%	3	3.41%				
45 - 54	15	16.31%	8	9.09%				
35 – 44	30	32.61%	26	29.54%				
25 - 34	33	35.87%	42	47.73%				
24 and below	10	10.87%	9	10.23%				
Gender								
Male	15	16.30%	12	13.64%				
Female	77	83.70%	76	86.36%				
Civil Status								
Single	35	38.04%	40	45.45%				
Married	56	60.87%	48	54.55%				
Widowed	1	1.09%	-	-				
Science Level Taug	ht							
Grade 3/7	13	14.13%	21	23.87%				
Grade 4/8	31	33.70%	24	27.27%				
Grade 5/9	16	17.39%	22	25.00%				
Grade 6/10	32	34.78%	21	23.86%				
Teaching Experience (years)								
21 or more	1	1.09%	-	-				
16 - 20	4	4.34%	5	5.68%				
11 – 15	7	7.61%	9	10.23%				
6 - 10	10	10.87%	15	17.04%				
0-5	70	76.09%	59	67.05%				
Position								
Teacher 1	77	83.70%	79	89.77%				
Teacher 2	2	2.17%	6	6.82%				
Teacher 3	11	11.96%	-	-				
Master Teacher 1	2	2.17%	3	3.41%				
Educational Attainment								
Bachelor's degree	76	82.61%	74	84.09%				
Master's degree	16	17.39%	13	14.77%				
Doctorate degree	-	-	1	1.14%				

Table 2. Level of Scientific Literacy of Science Teachers

	Elementary (n=94)		High School (n=88)		
Component	Score	Mean	Score	Mean	p-value
	Mean \pm SD	Percent	Mean \pm SD	Percent	
Nature of Science	14.70 ± 2.40	66.82%	14.97 ± 2.48	68.03%	0.424^{NS}
Science, Technology, and Society	10.60 ± 1.98	66.25%	11.40 ± 1.59	71.20%	0.000^{NS}
Physical Science	9.27 ± 1.94	61.80%	9.74 ± 2.03	64.09%	0.118 ^{NS}
Earth and Space Science	10.70 ± 2.28	76.43%	11.74 ± 1.72	83.85%	0.000*
Life Science	18.10 ± 2.67	75.42%	19.72 ± 2.34	82.15%	0.000*
Health Science	14.10 ± 2.57	74.21%	15.91 ± 2.41	83.73%	0.000*
Overall Scientific Literacy	77.13 ± 8.43	70.12%	83.47 ± 7.01	75.88%	0.000*

*significant at 0.05 level, NsNot significant

4. **DISCUSSION**

The profile of elementary and high school science teachers in Cagayan de Oro City is not different from different parts of the country. This case is very understandable since the promotion scheme in the Department of Education is very competitive and slow at the same time. Limited items are available for promotion and ranking. Most of the respondents also hold a bachelor's degree, while only a few possess a relevant master's degree. This could be due to the limited graduate programs offered for elementary science teachers in the region. As of this writing, no available master's degree is suited for elementary science teachers to advance their science content further. Much of the universities in the region offer a highly specialized graduate program for secondary teachers and graduate programs majoring in educational administration and supervision. These results are contrary to neighboring Asian countries like in Taiwan and Singapore, where 79% of their teachers possess a postgraduate degree, and the disparity between gender is very minimal [12]. Moreover, teachers in the Department of Education do not enjoy ample support for professional development, which could be one of the reasons for displeasure among them [13].

The promotion of scientific literacy (SL) has been recognized to be the primary goal of science education [4]. Due to this enormous importance in the state of science education, examining the level of SL of in-service elementary and high school science teachers is essential. It is good to note that the component where science teachers scored highest in the earth and space science. This component is considered to be the least covered course in the curriculum for general science teachers, as confirmed by informal interviews made by the researchers. This component is closely followed by life science and health science, which are all also extensively covered in the curriculum for general science teachers. It is not surprising that NOS, STS, and Physical Science had the lowest level since these components are least emphasized in the curriculum for both elementary and high school science teachers. This result is similar to Taiwanese pre-service teachers were NOS, and Physical Sciences were noted to be the lowest literacy level [4].

In terms of the content covered by teachers, most of the learning competencies in the new K to 12 curriculum emphasizes earth and space science and life science. This supports the idea that teacher knowledge and instructional experience and expertise are correlational [14]. This means that teachers master concepts more when they regularly and consistently make an effort to teach these to their students. Furthermore, when teachers research concepts they least understand and teach it to their students, it contributes to their understanding of those topics. Thus, the abundance of learning competencies in earth and space science and life science may have added to their high levels of SL in these domains. Similarly, there are few learning competencies in chemistry and physics in the K to 12 curriculum, and this may have contributed to their relatively lowest level of scientific literacy in physical science. In addition, elementary science teachers often teach many science subjects but not necessarily be equally effective in teaching in all of them [15]. Moreover, as suggested by many constructivist theorists, a person develops knowledge when he discovers, reconstructs, or rediscovers a specific knowledge. In this case, some of the concepts covered in TBSL might have been learned by the teachers in their formal education. Still, during their in-service experience, they were able to discover some new concepts or even reconstruct or revise their preexisting knowledge, thus giving them a more meaningful knowledge [16]. Moreover, the differences noted in the levels of scientific literacy could be because high school teachers teach more advanced science concepts than elementary science teachers. This further supports the idea that instructional experience is correlated with teacher knowledge.

In terms of the overall scientific literacy, the elementary (70.12%) and high school (75.88%) science teachers possess a satisfactory level of scientific literacy as compared to the passing score set by Laugksch & Spargo (1996) to be 62% or 68 out 110 questions. Excellent content knowledge is fundamental since this can be translated well into pedagogical content knowledge [17]. Although the overall level is satisfactory, literacy in terms of physical science did not reach the passing score for elementary science teachers. Compared to results from other studies on preservice elementary science teachers, the results of this study were found to be better. In a study conducted by Cavas, Ozdem, Cavas, Cakiroglu, & Ertepinar (2013), preservice teachers were found to possess 68.47% in their first year while 73.79% in their fourth year.

This indicates the more exposure in science courses would lead to better scientific literacy levels. This supports the results of this study since although the overall scientific literacy is satisfactory, it is not that high, and this could be due to the limited experience of the respondents where a majority (76.09%) have less than five years of teaching experience.

5. CONCLUDING STATEMENTS

The profile of the elementary teachers (n=92) and high school (n=88) surveyed in terms of age, ranges from 25 - 44years old, with 0-5 years of experience, possessing a rank of Teacher 1, has a bachelor's degree qualification, and most are female and married. These results are highly comparable to findings in other literature. The respondents scored satisfactory in terms of overall scientific literacy. Respondents faired most in earth and space science. This was believed to be due to the fact the topics in this subject are well covered in all levels of the science curriculum. This was followed by life science and health science. Respondents scored least and below the passing rate in the physical science component. This may be due abstract and difficult nature of this component. Although low, the scores are considerably better than what was found in the literature. In designing the elementary teacher curriculum, ample subjects added should be able to address the gaps in terms of the nature of science, science, technology, and society, and physical sciences content knowledge. These content can either be improved by adding separate courses (for NOS, STS, and physical sciences) or improving instruction by integrating NOS and STS in other allied science courses. Additional physical sciences content can also be explored in the design.

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