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A Canonical Correlation Analysis of Filipino Science Teachers' Scientific Literacy and Science Teaching Efficacy

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Science teacher's self-efficacy has been at the center of many investigations on students' achievement in science, teacher burnout, and teacher performance. While overly studied, this construct has not been examined with scientific literacy in depth. Thus, this study aims to identify the influence of science teacher's scientific literacy on their science teaching efficacy through a canonical correlation analysis. The study utilized an explanatory-correlational research design to unravel the correlation between scientific literacy and science teaching efficacy. It was found out that scientific literacy was correlated with science teaching efficacy. Further the study revealed that Science, Technology, and Society (STS) and content knowledge in earth science, life science, and health science were positively associated with science teachers' self-efficacy in biology, chemistry, and physics. On the other hand, knowledge in physics and Nature of Science (NOS) were not associated as highlighted in the literature. This suggests that a science teacher's content knowledge in specific sciences predicts their efficacy in teaching science. More so, the teacher's knowledge of how science and technology affect society and how society directs science and technology shapes their confidence to teach science. This implies that practical and observable science allows teachers to demonstrate science concepts to their students effectively.

Keywords: teacher efficacy, science teaching, teacher education, science, teacher

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INTRODUCTION

In the last few decades, educators have emphasized developing scientific literacy in science education programs (Demirel & Caymaz, 2015; Gencer & Cakiroglu, 2007). In addition, the goal for studying science courses in school is the attainment of scientific literacy (Holbrook & Rannikmae, 2007). To prepare students to do well in science, the science teacher is often considered to be one of the most influential factors in increasing the quality of student's total science learning outcomes. In addition, teachers are vital in improving scientific literacy achievement at all levels of education (Cakiroglu, Capa-Aydin, & Hoy, 2012; Demirel & Caymaz, 2015; Walag, Fajardo, Guimary, & Bacarrisas, 2020). However, previous studies have indicated that many pre-service and in-service teachers possess low to satisfactory confidence in their abilities to teach science and help students learn (Cakiroglu et al., 2012; Demirel & Caymaz, 2015; Walag, Fajardo, Guimary, et al., 2020). As such, we must first investigate how to effectively prepare our pre-service teachers and further improve our in-service teachers for science teaching if we want to address scientific literacy concerns of our citizenry. This is so since the success of science education reforms is contingent on the development of science teacher's self-efficacy (Flores, 2019).

Scientific literacy is often regarded as the knowledge and understanding of the fundamental scientific ideas and processes necessary for personal decision-making (Cavas, Ozdem, Cavas, Cakiroglu, & Ertepinar, 2013; Walag, Fajardo, Bacarrisas, & Guimary, 2020). Despite the fact that there is no commonly recognized definition of scientific literacy (Roberts, 2007), instructors at all levels of education play an important role in building student's scientific literacy. For them to effectively impart scientific literacy, they must have set outstanding levels of scientific literacy. Similarly, it is accepted long ago that good teacher knowledge helps improve the literacy of students (Druva & Anderson, 1983). Thus, the importance of science teacher's level of scientific literacy towards science teaching couldn't be more emphasized.

Self-efficacy beliefs are defined as a teacher's assessment of his or her ability to produce desired learning outcomes and to engage pupils in learning and performance. (Bal-Taştan et al., 2018). Self-efficacy beliefs have a significant influence in deciding teaching methods, such as selecting suitable learning activities, arranging lessons, and equipping oneself for tough and hard circumstances. (Bandura, 1997). Several reports have been made highlighting that teacher with relatively higher self-efficacy exhibit an inclination towards the use of student-centered approaches, which later could be beneficial to students (Cakiroglu et al., 2012; Flores, 2019).

As noted by Bandura, the self-efficacy construct is situation-specific. This suggests that teachers may seem highly capable in teaching one topic but less capable in teaching another. (Tschannen-Moran, Hoy, & Hoy, 1998). This is due to the fact that each topic has its own epistemological foundations, which entails the utilization of diverse teaching strategies, methods, and competencies. This indicates that some teachers may find it challenging to teach Biology or Earth Science compared to Physics or Chemistry to high school students. This highlights the importance of understanding the different subject-specific self-efficacy of science teachers in teaching other science subjects as science is taught in a spiraling approach (Walag, Fajardo, Guimary, et al., 2020).

The teacher's self-efficacy beliefs have been consistently found to be correlated between teacher classroom behavior and student achievement. Furthermore, teachers who exhibit openness to new ideas, demonstrate greater levels of planning and enthusiasm, and are committed to their profession have higher levels of self-efficacy (al Sultan, Henson, & Fadde, 2018; Flores, 2019). More so, a moderate self-efficacy level was also correlated with teacher's scientific literacy (Schoon & Boone, 1998). Although there was a correlation, caution must be taken into consideration since a general correlation was only observed and not considering that scientific literacy and self-efficacy are multifaceted variables. Schoon and Boone (2016) found that pre-service teachers who possessed fewer alternative conceptions had higher efficacy levels. However, Morrell and Carroll (2003) claimed that science content knowledge is insufficient to improve teacher self-efficacy. This highlights the existing debate on how scientific literacy is correlated with self-efficacy. Thus, this study builds on the correlation between teacher's scientific literacy and self-efficacy by utilizing a method not previously used in the literature, canonical analysis, in an attempt to bring clarity to this important, teacher curriculum-relevant question. As such, this paper seeks to address the following research questions:

1. What are science teachers' levels of scientific literacy, science teaching efficacy, and subject-specific self-efficacy?
2. How well do science teachers' scientific literacy levels predict their science teaching efficacy and subject-specific self-efficacy?

Literature Review

Scientific Literacy

Scientific literacy is described as the capacity to understand and make judgments about nature and its changes as a result of human activity by using scientific knowledge, in forming questions and making judgments based on evidence. (Bacanak & Gökdere, 2009). Others describe it as a person's capacity to think critically and sensibly about science in the context of everyday personal, societal, and economic issues. (Altun-Yalçn, Açşli, & Turgut, 2011; Cavas et al., 2013). Others, on the other hand, regard it as the ability to understand both the social consequences of science and technology as well as the nature of science. (Holbrook & Rannikmae, 2009). Although several definitions exist, it has been used in the literature for more than five decades (Maienschein et al., 1998). There is extreme difficulty in defining and giving clarity of meaning to the term scientific literacy. The National Science Teaching Association (NSTA), as part of the Science-Technology-Society (STS) movement, proposed that a scientifically and technologically literate individual needs intellectual competence and other traits. These components (2009) are intellectual, attitudinal, societal, and interdisciplinary capabilities, as Holbrook and Rannikmae (2009) put forward. Indicators for these components can be found in their work.

Scientific literacy may also be divided into two types: (a) those who urge for science knowledge to play a major role in society, and (b) those who regard scientific literacy as referring to its utility in society. The first mode of thinking is based on the premise that basic scientific ideas are fundamental. This has been defined as a short-term approach to understanding science, and it has even been dubbed "science literacy" to distinguish it from a longer-term approach to "scientific literacy." (Rychen & Salganik, 2003). The other school of thought considers the long term and views scientific literacy to be a must for surviving in a fast - changing world. This emphasizes the need of linking scientific literacy to the development of life skills. (Holbrook & Rannikmae, 2009). This viewpoint acknowledges the importance of developing reasoning abilities in a social setting, and it emphasizes that science literacy is for everyone, not only scientists. (2002). A continuum of the two views was put forward by Graber et al. (2002), stretching between two extremes of subject competence and meta-competence. This paradigm emphasizes the need of scientific literacy as more than simply knowledge and incorporates values education as an important component of science education.. Thus in this area, scientific literacy encompasses socio-scientific decision-making skills (Liu, 2009; Shamos & Howes, 1996).

Scientific literacy has also been defined into three levels (Bybee, McCrae, & Laurie, 2009). The first is cultural scientific literacy which is the grasp of a specific background knowledge underlying basic communication. The second level is functional science literacy, where the person knows science terms and is capable of using them coherently to converse, read, and write in non-technical contexts. The last level is true scientific literacy, where the person understands the overall scientific enterprise the major conceptual schemes in science.

The definition put forward at the beginning of this section was later modified, and Programme for International Student Assessment (PISA) moved to determine three dimensions of scientific literacy (Holbrook & Rannikmae, 2009). These three dimensions are scientific concepts, scientific processes, and scientific situations. Scientific concepts are those that are required to comprehend certain natural events as well as the changes that have occurred as a result of human action. The ability to gather, understand, and act on data is fundamental to scientific processes. Lastly, scientific situations are those that are selected from people's day-to-day lives as opposed to the practice of science in schools. This further highlight that scientific literacy is purely at knowledge level and making decisions and acting as a responsible person (Bell & Lederman, 2003).

The understanding of the Nature of Science (NOS) has often been associated with the development of scientific literacy. This often becomes a problematic notion since NOS does not have one clear interpretation. Its context, like that of all philosophical concepts, is never static and is always changing. Whatever the interpretation, there is a consensus about what science is; even if other groups argue and emphasize different aspects of the NOS (Holbrook & Rannikmae, 2009), NOS in science education schools may be viewed from a variety of angles. For one, NOS can relate to the development of 'big ideas,' that scientific literacy, when defined and ignoring or not recognizing that the big ideas don't exist, rejects the interpretation of NOS. Secondly, few definitions of scientific literacy would omit the importance of how scientists work and the consideration of the variety of scientific methods and related to process skills. Thus, in relation to NOS, the definition emphasizes the skills required to extract and handle information (Holbrook & Rannikmae, 2007). Lastly, NOS is related in a social setting, encompassing socio-scientific decision-making. This relation is similar to how scientific literacy is defined by recognizing the need for decision-making within society's frame. This suggests that NOS is vital in science education curriculum targeting responsible citizenry production through scientific and technological literacy (AAAS, 1989).

The broadest idea on scientific literacy is that of the American Association for the Advancement of Science (AAAS). They define scientific literacy as encompassing mathematics and technology as well as the social and natural sciences (Laugksch & Spargo, 1996). Thus, according to AAAS, a scientifically literate person is aware that science, mathematics, and technology are interdependent human venture with certain strengths and limitations, who also understands the key science principles and concepts, who recognizes the unity and diversity in the natural world, and who uses scientific ways and thinking to solve personal and social struggles.

Laugksch and Spargo (1996) created the Test for Basic Scientific Literacy (TBSL) based on the AAAS concept of scientific literacy. The TBSL includes a 110 item true-false-don't know test covering the nature of science, impacts of science and technology on society, and science content knowledge (earth science, life science, physical science, and health science).

Self-Efficacy

Self-efficacy, a core idea in social cognitive theory, has been written in a growing literature in medicine, psychology, education, and business administration since Albert Bandura's (1977) Unifying Theory of Behavioral Change. Perceived self-efficacy beliefs refer to the personally held beliefs about one's ability to perform actions at certain levels (Cakiroglu et al., 2012). The definition of self-efficacy has been often synonymized with self-concept, self-esteem, and locus of control. Tschannen-Moran et al. (1998) pointed out that although these concepts are self-referential, self-efficacy is different as it requires evaluation of one's capabilities to a particular task.

Since self-efficacy is task-based, a teacher's self-efficacy has been defined as a teacher's belief in his or her capacity to plan and carry out courses of action that are required to accomplish a teaching task in a specific context (Bandura, 1997; Cakiroglu et al., 2012; Digal & Walag, 2019). Further, the same authors proposed that teacher self-efficacy is a result of the interaction between the analysis of teaching tasks in context and the analysis of personal teaching capabilities. This resulting efficacy influences the professional goals, expenditure of effort, and the resilience of teachers.

Four aspects influence self-efficacy; mastery experience, vicarious experience, verbal persuasion, and emotional arousal (Bandura, 1997). The most potent source is mastery experiences, because they provide true and intimate evidence that a person can perform the desired activity. Vicarious experiences are also powerful since they include an individual observing and gaining confidence from another person's performance. One example of vicarious experiences is when teachers are provided with opportunities to observe an accomplished colleague or mentor. Verbal persuasion, on the other hand, is given by other people and can have a positive or bad impact on a person's confidence. Finally, emotional arousal, tension, anxiety, or overall thoughts about a task can all have an impact on one's belief in one's ability to do it.

Bandura’s definition of self-efficacy as both subject-matter and context-specific constructs has been reinforced by Riggs and Enoch (1990) through their development of an instrument to measure science teaching efficacy. This instrument, Science Teaching Efficacy Belief Instrument (STEBI), was from the work of Gibson and Demo, where Riggs and Enoch identified two unrelated factors within STEBI, the personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE).

The STEBI has been used as a base instrument in developing several subject-matter-specific instruments. Rubeck and Enochs (1991) developed STEBI-CHEM to assess chemistry teaching efficacy while Sia (1992) developed Environmental Education Efficacy Belief Instrument (EEEBI) to assess teacher efficacy beliefs on environmental education. Walag, Fajardo, Guimary, et al. (2020) built on the subject specificity of self-efficacy beliefs and developed a Subject-Specific Self-Efficacy (SSSE) instrument which aims to assess teacher's efficacy in teaching different concepts in sciences. They then formulated the earth and space science efficacy, biology efficacy, chemistry efficacy, and physics efficacy. This instrument was utilized to determine the science teaching efficacy levels of teachers from different cities in the Philippines and has been used in a project monitoring on teacher’s development of teaching efficacy (Bug-os, Besagas, Gabunilas, & Walag, 2021; Bug-os, Walag, & Fajardo, 2021; Walag, Fajardo, Guimary, et al., 2020).

Present study

Based on the ongoing debates on scientific literacy and self-efficacy, this study hypothesizes that scientific literacy and science teaching self-efficacy are correlated, as shown in Figure 1. The present study uses the definition of scientific literacy from the AAAS and utilizes the TBSL (Laugksch & Spargo, 1996), while for the self-efficacy, the definition of Riggs and Enochs (1990) is used through the STEBI. Furthermore, an extension of the science teaching self-efficacy construct was made through the use of the SSSE instrument of Walag, Fajardo, Guimary, et al. (2020).

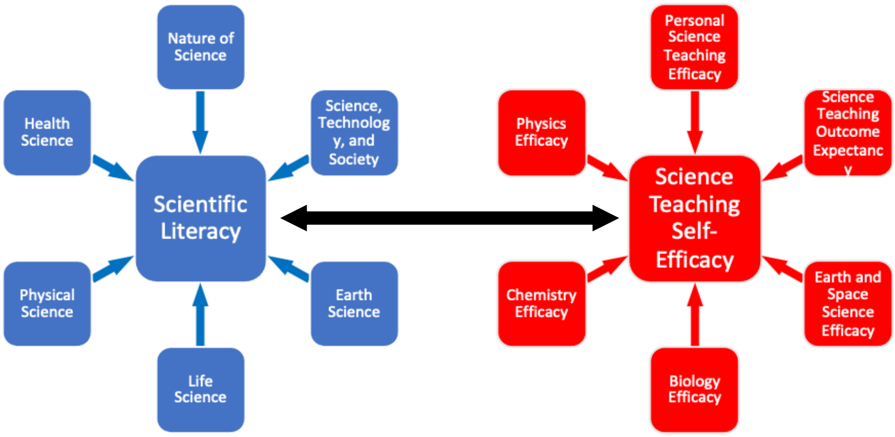

Figure 1
Hypothetical model showing the relationship between Scientific Literacy and Science Teaching Self-Efficacy

METHODS

Research Design and Sample

This present study utilizes an explanatory-correlational research design to unravel the relationship between two sets of variables, scientific literacy, and science teaching self-efficacy. An explanatory-correlational research design seeks to determine to what extent the two or more variables co-vary (Cebesoy & Öztekin, 2016). The study involved 180 primary and secondary science teachers selected from all government-run schools while attending several seminars and workshops organized by the Department of Education in Cagayan de Oro City. Teacher-participants were informed about the nature of the study and were given a choice to respond to the survey. Submission of their questionnaire was taken as an indication of their informed consent and willingness to participate in the research. The demographics are summarized in Table 1.

Table 1
Distribution of participating science teachers according to their teaching qualifications and experience

Teaching Qualifications	Primary School (n=92) %	High School (n=88) %
Gender		
Male	16.30	13.64
Female	83.70	86.36
Teaching Experience		
21 years or more	1.09	-
16 – 20 years	4.34	5.68
11 – 15 years	7.61	10.23
6 – 10 years	10.87	17.04
0 – 5 years	76.09	67.05
Position		
Teacher 1	83.70	89.77
Teacher 2	2.17	6.82
Teacher 3	11.96	
Master Teacher 1	2.17	3.41
Educational Attainment		
Bachelor’s	82.61	84.09
Master’s	17.39	14.77
Doctorate	-	1.14

Measurements

The instrument referred to as Test for Basic Scientific Literacy (TBSL) was developed by Laugksch and Spargo (Laugksch & Spargo, 1996) based on AAAS's literacy goal recommendations in Science all Americans. Based on the constitutive components of scientific literacy(Miller, 1983), the TBSL consists of three subtests: the nature of science (22 things), science content knowledge (72 items), and the impact of science and technology on society (16 items). The Science Teaching Efficacy Belief Instrument (STEBI), created by Riggs and Enoch, was used to assess science teachers' self-efficacy (1990). PSTE (Personal Science Teaching Efficacy) and STOE (Science Teaching Outcome Expectancy) are the two components of this instrument (STOE). The subject-specific self-efficacy (SSSE) instrument developed by Walag, Fajardo, Guimary, et al. (2020) was used to measure teachers' teaching confidence in teaching four components of science, earth and space science, biology, chemistry, and physics. The instruments were pilot-tested by administering to 113 science teachers and subsequently modified before producing the final version. The Cronbach's alpha for TBSL was 0.83, while 0.81 for STEBI and 0.95 for SSSE.

Statistical Analysis

In existing researches in science education, canonical correlation analysis is rarely used. Canonical correlation analysis is a method that can accommodate multiple inputs and output variables (Knoeppel, Verstegen, & Rinehart, 2007), in this case, scientific literacy and science teaching self-efficacy. In canonical analysis, two linear combinations are formed, one of the predictor variables and one of the criteria variables, weighted differentially to attain the maximum correlation between these variables (Tabachnick & Fidell, 2012). In this study, the independent variables are scientific literacy dimensions while the dependent variables science teaching efficacy, science teaching outcome expectancy, and subject-specific self-efficacy.

Assumptions for the canonical correlation analysis were determined as suggested by Cebesoy and Öztekin (2016). Normality, skewness, and kurtosis values were determined and found to be between the ranges of +2 and -2 (Pallant, 2011). The multicollinearity assumption was determined using Pearson's product-moment correlations shown in Figure 2, and none exceeded 0.80 were detected. Mahalanobis distance values were compared with the critical values, and the presence of multivariate outliers was not detected as suggested by Pallant (2011).

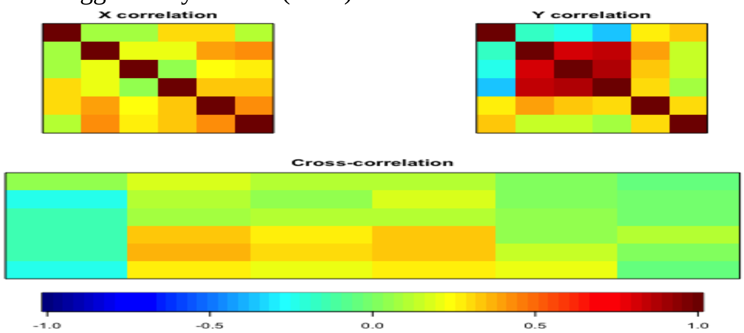

Figure 2
Heatmap showing the bivariate correlation of the variables of scientific literacy, science teaching self-efficacy, and their cross-correlation

FINDINGS

Science Teachers' Scientific Literacy Levels

As shown in Table 2, the majority of the respondents correctly answered all dimensions of the TBSL. The dimensions where the most number of participants got correct answers are in Earth Science, Health Science, and Life Science. This implies that science teachers have a moderate level of literacy in terms of earth science, life science, and health science. More so, this indicates that science teachers are more aware of the important content knowledge in these dimensions. This content knowledge includes the universe, the earth, the processes that shape the earth, diversity of life, heredity, cells, the interdependence of life, evolution, human development, physical and mental health. The dimension where most science teachers got incorrect responses is in Physical Science. Overall, science teachers possess satisfactory scientific literacy levels in all dimensions as it exceeded 62%, the passing score set by Laugksch and Spargo (1996). Although satisfactory in all dimensions, much attention should be given to these teachers' physical science content knowledge as their score is almost equal to the passing score. This suggests that teachers have difficulty in recalling essential content knowledge on the structure of matter, energy transformations, motion, and the forces of nature.

Table 2
Descriptive statistics of the science teachers’ scientific literacy levels

Dimension	No. of items	Mean	Standard deviation	Mean % score
Nature of Science (NOS)	22	14.82	2.44	67.35
Science, Technology, and Society (STS)	16	10.99	1.84	68.72
Physical Science (PS)	15	9.50	2.00	63.33
Earth Science (ES)	14	11.06	2.13	79.01
Life Science (LS)	24	18.87	2.64	78.61
Health Science (HS)	19	14.99	2.55	78.89
Total	110	80.23	8.42	

Science Teachers’ Teaching Efficacy and Subject-Specific Self-Efficacy

The descriptive statistics of science teacher's personal science teaching efficacy, science teaching outcome expectancy, and subject-specific self-efficacy are summarized in Table 3. As shown, science teachers possess a satisfactory level of self-efficacy in all dimensions. This acceptable level of PSTE indicates that teachers are more likely to exert great effort to accomplish their teaching objectives and have persistence in facing different teaching obstacles. These same teachers also believe that their confidence in effective teaching could result in positive learning. In terms of self-efficacy in teaching other science subjects, teachers have comparable efficacy in earth and space science, biology, and chemistry. In the four areas, teachers seemed relatively least confident in teaching physics.

Table 3
Descriptive statistics of science teachers’ self-efficacy

Dimension	Mean	Standard deviation
Personal Science Teaching Efficacy (STE)	3.16	0.42
Science Teaching Outcome Expectancy (STOE)	3.06	0.34
Earth and Space Science Efficacy	3.28	0.48
Biology Efficacy	3.27	0.51
Chemistry Efficacy	3.26	0.56
Physics Efficacy	3.10	0.55

A canonical correlation was performed to investigate the relationship between science teachers' scientific literacy (nature of science, science, technology, and society, physical science, earth science, life science, and health science) and science teaching self-efficacy (personal science teaching efficacy, science teaching outcome expectancy, earth and space science efficacy, biology efficacy, chemistry efficacy, and physics efficacy). Table 4 shows the tests for dimensionality for the canonical correlation analysis indicating that two of the six canonical dimensions are statistically significant at the 0.05 level. Dimension 1 a canonical correlation of 0.45 (λ = 0.637) between the sets of variables while for dimension 2, the canonical correlation was at 0.32 (λ = 0.800).

Table 4
Tests of canonical dimensions using wilk's lambda

Dimension	R_c	F	df1	df2	p	R_c^2
1	0.451	2.22	36	740.50	0.000*	0.203
2	0.317	1.55	25	629.31	0.042*	0.100
3	0.279	1.27	16	520.00	0.214	0.078
4	0.165	0.68	9	416.32	0.728	0.027
5	0.087	0.33	4	344.00	0.855	0.007
6	0.000	0.00	1	173.00	0.995	0.000

*Significant at 0.05 level

Figure 3 graphically shows the canonical loadings of the different variables of scientific literacy and science teaching self-efficacy. The inner-circle represents the cutoff correlation of 0.3 (Cebesoy & Öztekin, 2016). Those variables that exceeds the 0.3 signifies that these variables are correlated to the canonical covariate. As shown in Figure 3a, the first canonical covariate was positively correlated with their content knowledge in science, technology and society, health science, earth science, life science, and subject-specific self-efficacy in biology, physics, and chemistry. The first pair of canonical variates demonstrated that a science teacher with satisfactory science content knowledge in STS, HS, ES, LS, and NOS, held a positive self-efficacy in teaching physics, chemistry and biology. The second pair of canonical variate was found to be positively correlated with STS and negatively correlated with NOS and LS. The second pair of canonical variate demonstrated that science teachers who possess satisfactory literacy in NOS and LS were likely to be less literate in STS.

Figures 3b and 3c, on the other hand, demonstrates the standardized canonical coefficients of for the first two significant canonical dimensions for scientific literacy and self-efficacy. As shown in Figure 3b, for scientific literacy, the first canonical dimension is most strongly influenced by ES, LS, and HS and STS for the second canonical dimension. In terms of science teaching efficacy, the first dimension was comprised of BE and ESE. No significant influence was found on the second dimension.

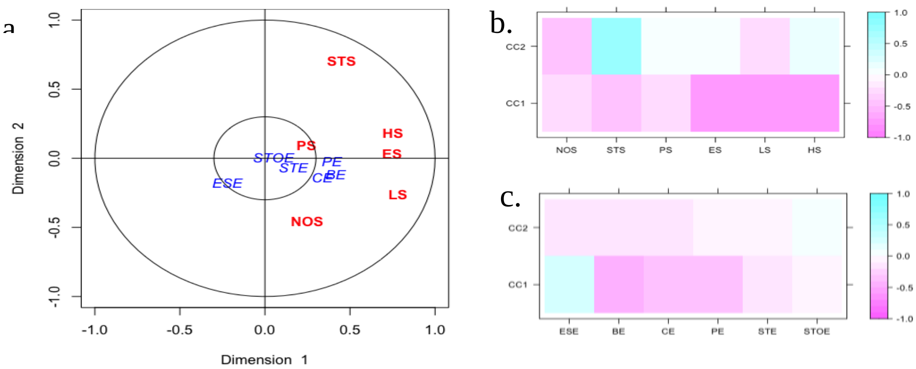

Figure 3
Graphical plot of the canonical loadings of the variables on the canonical dimensions

The inner-circle represents the cutoff correlation at 0.3 (a). Heatmap showing the standardized canonical coefficients for the first two canonical dimensions across scientific literacy (b) and science teaching efficacy (c) variables

DISCUSSION

A scientifically literate person is an individual capable of understanding scientific laws, phenomena, and things (Dragoş & Mih, 2015). It is considered a yardstick for a country's quality of science education (Rubini et al., 2016). As a result of their critical role in education at all levels, science instructors have been entrusted with the job of generating scientifically educated citizens. (Shamos & Howes, 1996). As a result, teachers must have at least a basic degree of scientific literacy in order to successfully teach it to their students (Walag, Fajardo, Bacarrisas, et al., 2020). Other than the teachers' level of scientific literacy, their self-efficacy beliefs also shape how they facilitate science learning. The way science teachers teach science is affected by both scientific literacy and science teaching efficacy (al Sultan, 2016). Teachers who possess high self-efficacy beliefs are more likely to use inquiry-based practices than those with low self-efficacy, relying only on textbooks and other prescribed learning materials (Ramey-Gassert, Shroyer, & Staver, 1996). More so, lesson progression in the classroom are still often shaped by teachers decision on what students should achieve (Saleh & Jing, 2020). Several studies have been published that highlight the various components that influence teachers' self-efficacy views, while there are still disagreements. The purpose of this study was to see how much science teachers' levels of scientific literacy predict their science teaching efficacy.

Besides providing information about science teachers' level of scientific literacy and science teaching efficacy, the findings also provided important clues regarding the factors that might influence science teacher's science teaching efficacy. First, a statistically significant relationship was found to exist between scientific literacy and science teaching efficacy. These results suggest that the relationship between scientific literacy and science teaching efficacy does exist, and it explained a moderate amount of variance (total pooled variance 30%). In particular, science teachers who possess high literacy levels in STS, ES, LS, and HS have higher confidence in teaching biology, chemistry, and physics. This result supports the notion that self-efficacy is not just situation-specific but also subject-specific. More so, effective science teaching generally involves utilizing strategies that improve conceptual understanding (Johnson, 2007). Thus, science content knowledge in generally observable sciences like earth science, life science, and health science allows a teacher to demonstrate science into something tangible for the students. This then improves their science teaching efficacy. In addition, concepts and theories in physical sciences are mostly abstract in nature. Thus teachers may find difficulty in teaching these, and that affects their science teaching efficacy. Similarly, Wright and Wright (1998) posited that "one cannot teach, model, or support what one does not know, feel, or accept" (p. 137). More so, Bandura (1977) highlighted that the mastery experience provides the most potent source of self-efficacy. Further, the results confirm the findings of other science education scholars that, indeed, self-efficacy and scientific literacy are related (Latifah, Susilowati, Khoiriyah, & Rahayu, 2019; Catalano, Asselta, & Durkin, 2019), whether examined holistically or analytically. This is significant as teacher's literacy and efficacy significantly shape student's learning outcomes (Sum et al., 2018).

Further, the present study disagrees with the notion that science teaching self-efficacy is only determined by the teacher's confidence in performing specific tasks in the classroom (STE) and towards students' achievement of desired outcomes (STOE) (Riggs & Enochs, 1990). Moreover, this study also supports that science teachers' STE and STOE are not influenced by their science content knowledge (Abdelmoneim & Hassan, 2012). Nonetheless, science teachers' efficacy in teaching individual science subjects has a greater impact on their science teaching efficacy. This supports the findings of Lawson (1994) that each science subject requires different sets of teaching strategies, methods, and skills. Although this highlights the subject-specific nature of science teaching efficacy, this could also be interpreted as situation-specific, in this case the situation meant was the subject, and that in some situations require greater skills and more arduous performance (Bandura, 1986). Thus, teachers may have different levels of confidence in teaching different fields of science. It is also noteworthy to mention that STS influences teachers' self-efficacy most. This highlights the importance of the knowledge teachers on how science and technology shape society. Teachers do not just teach science content knowledge but are also aware of science and technology that affect the world around us, which influences science teaching efficacy. This suggests that the definition of scientific literacy through science education of Holbrook and Rannikmae (2009) should emphasize an appreciation of NOS and take into consideration the influence of STS. In addition, teaching efficacy of teachers are also affected by their adaptation to their profession and their optimism towards teaching career in general (Tezer, Guldal Kan, & Bas, (2019).

CONCLUSION AND IMPLICATIONS

In this study, the correlation between science teachers' level of scientific literacy and science teaching efficacy was analyzed using a canonical correlation. A positive and moderate relationship exists between scientific literacy and science teaching efficacy. The main components of scientific literacy that influence science teaching efficacy are the content knowledge in STS, ES, LS, and HS. This finding suggests that science teaching efficacy is not only situation-specific but also subject-specific. Science teachers possess high self-efficacy when teaching science subjects that they are knowledgeable in. This study confirms the longstanding notion that scientific literacy influences science teaching efficacy in specific subjects, while no significant correlation was found in the personal science teaching efficacy nor science teaching outcome expectancy.

The present study has some limitations that may have implications for further studies. Firstly, the present work was based on a small sample of primary and secondary school teachers in Cagayan de Oro City, which may not represent all science teachers' scientific literacy levels and science teaching efficacy in the Philippines. Although the results provided us with some clues on how scientific literacy influences science teaching efficacy, a more extensive study involving many participants would be more desirable. Second, the study relied on self-perceived measures to assess personal scientific teaching efficacy as well as subject-specific self-efficacy, which may not adequately assess their science teaching efficacy. Self-reported data may not always provide an accurate snapshot of teacher's actual beliefs (Boateng & Sekyere, 2018). As this study was exploratory in nature, further studies may be done utilizing qualitative or even experimental methods. Furthermore, other confounding variables (i.e., educational attainment, gender, experience, etc.) may be explored and not covered in this analysis.

The studies had some limitations; the results still provide meaningful and practical implications for teacher education curriculum and teacher professional development. Because self-efficacy beliefs are formed early in life, a focus on the development of high levels of science subject knowledge and STS is desired in the design of the teacher education curriculum to build science teachers' science teaching efficacy.. In terms of in-service teachers' professional development, attention may be given to further improving their scientific literacy to effect quality science teaching.

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