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ORIGINAL ARTICLE

Ecological Knowledge of Pre-Service Science Teachers: Conceptual Interrelationships and Association with Senior High School Strand

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ABSTRACT

Ecological knowledge is one of the components of environmental literacy that refers to the ability of people to understand and apply acquired knowledge about ecology to achieve a grasp of how nature works and their interactions with the social system. This study aimed to determine pre-service science teachers' level of ecological knowledge in Cebu City, Central Visayas, Philippines, and their relationship to their senior high school (SHS) strand. A validated 40-item multiple-choice Ecological Knowledge Test (Cronbach's $\alpha = 0.759$) was administered to 66 pre-service science teachers selected through convenience sampling. The results were analyzed through descriptive statistics, one-sample *t*-test, analysis of variance, path analysis, and non-parametric correlation tested at a 95% confidence level. The study results revealed that the pre-service teachers had "Above Average" knowledge of ecology and its major, related, and other concepts. These concepts did not have significant differences among them but showed a significant effect on ecological knowledge. SHS strand did not show significant association with the said knowledge. Therefore, the pre-service science teachers were ecologically and environmentally literate. To increase ecological knowledge continually, they should be exposed to ecological and environmental immersion to gain awareness and knowledge and develop an in-depth appreciation for the ecosystems.

KEY WORDS: Ecological knowledge; pre-service science teachers; senior high school strand

INTRODUCTION

Humans and nature are inextricable because both, directly and indirectly, affect each other; as such, a change in the human condition could lead to changes in the environment. These changes have affected countries where environmental deterioration is increasingly evident (Nwankwoala, 2015). For example, different calamities (e.g., typhoons) have become more deadly and stronger than they were climate conditions change unusually as observed in very high heat index in tropical countries (e.g., Philippines), more glaciers melting in the polar regions (e.g., Alaska in the USA); and biodiversity loss increases due to people's illegal activities in the habitats (e.g., Sea of Cortes in Mexico). However, these consequences may not be experienced by people when they are environmentally literate, especially knowing and understanding the ecology of their surroundings.

Environmental literate people can work individually or collaboratively with others to make informed decisions toward actions that benefit the environment and eventually lead to sustainability (Hollweg et al., 2011). One of the characteristics of environmentally literate people is their knowledge and understanding of ecological concepts, referred to as "ecological knowledge" (Erdogan et al., 2009). Ecological knowledge also refers to understanding how nature and its systems work and how these systems interface with society and its systems (Simmons, 1995). In other words, such knowledge includes the underlying links people have with the environment. Knowing the ecology of one's environment is essential to learn to predict, extinguish, counteract, and prevent potential consequences of human activities on the planet. Ecological knowledge should then be understood in different human strata, including the pre-service science teachers.

This study investigated the level of ecological knowledge of the pre-service science teachers in a public university in Central Visayas, Philippines. Pre-service teachers are crucial in the students' growth and development, and through education, they can encourage and increase awareness and concerns to their students and other people. Furthermore, classroom initiatives such as eco-friendly procedures and school/community-wide activities such as tree-planting and coastal clean-ups may lead to a "change" in the students and other community members. This illustrates how important it is to be ecologically knowledgeable; hence, the necessity for this study.

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Some Studies about Environmental and Ecological Knowledge

As a component of environmental literacy, knowledge about the environment or ecology has been studied in the literature. Tuncer et al. (2009) investigated the environmental literacy of pre-service teachers in a Turkish university. Results showed that only slightly less than half of the pre-service teachers received passing environmental knowledge. Moreover, their knowledge has a significant relationship with their attitudes but on environmental use and concern. Hence, Tuncer et al. (2009) call for appropriate teaching strategies for equipping future teachers with the necessary knowledge, skills, and attitudes.

Another study by Karpudewan et al. (2013) explored the specific ecological concepts of Malaysian pre-service teachers, specifically on traditional ecological concepts and sustainable development concepts. The respondents had high awareness and understanding of the traditional concepts but moderate-to-low awareness and understanding toward sustainable development concepts. The results of Karpudewan et al. (2013) call for effective integration of traditional and sustainable concepts in class.

In addition, Sadik and Sadik (2014) investigated teacher candidates' knowledge in science, technology, engineering and mathematics (STEM) and social sciences departments. Their study on Turkish teacher candidates found that the candidates had a moderate level of environmental knowledge, with the social sciences department having greater knowledge than that of STEM. Therefore, Sadik and Sadik (2014) see environmental education classes as crucial to environmental knowledge as those teachers enrolled in such a class have higher knowledge.

Furthermore, Mashfufah et al. (2018) evaluated the environmental literacy of biology pre-service teachers using the aspects of knowledge, attitude, utilization perception, and problem concern. This Indonesian study found that most pre-service teachers had scored low, indicating that knowledge was a challenge for them. In addition, knowledge was found to be significantly correlated with attitude and problem concern.

Collating these related studies, it can be seen that there are few studies which have focused on the knowledge of ecology among pre-service science teachers. Hence, for this reason, the researchers conducted this study.

Purpose of the Study

This research aimed to determine the level of ecological knowledge of pre-service science teachers in a public university in Cebu City, Central Visayas, Philippines. Specifically, it sought to answer the following questions:

1. What is the level of ecological knowledge of pre-service science teachers in terms of:
   a. Major ecological concepts (MECs),
   b. Related concepts, and
   c. Other concepts?
2. Is there a significant difference among the levels of the three aspects of ecological knowledge?
3. Is there a significant relationship between the aspects of ecological knowledge?
4. Is there a significant relationship between the level of ecological knowledge and the strand of the pre-service teachers in Senior High School (SHS)?

RESEARCH METHODS

Research Design

The researchers employed the nonexperimental quantitative research, which aimed to determine the level of ecological knowledge among pre-service science teachers. In this design, the data were gathered through a face-to-face survey and analyzed through descriptive and inferential statistics. Surveys and correlational research studies are forms of the nonexperimental quantitative design (Cook and Cook, 2008).

Research Environment and Respondents

This study was conducted in a public university in Cebu City, Central Visayas, Philippines. This university takes pride in its teacher education programs as they are flagship programs in the locale. Graduates from the education programs top the licensure exams and have been outstanding in their field of specialization, including the science teachers. Therefore, the pre-service science teachers from the said institution were included in the study to determine their ecological knowledge, which is an important component of environmental education.

Pre-service teachers taking a Bachelor of Secondary Education with a specialization in Science participated in the study. Using Slovin's formula, the total target population of 80 resulted to the final sample of 66 pre-service teachers. The members of the sample were randomly selected through the fishbowl technique. In this sampling, slips of paper were placed in a fishbowl, and random papers were drawn from it. This is similar to the lottery technique, where randomly-drawn out names become part of the sample (Elfil and Negida, 2017). The demographic profile of the respondents is presented below Table 1.

The respondents' age bracket was between 18 and 20 years old, wherein 17 (25%) respondents were aged 18 years old, 43 (65%) of them were 19 years old, and 6 (10%) of them were 20 years old. In addition, 51 (77%) were females, and the other

Table 1: Demographic profile of pre-service science teachers

Profile	Category	f (n=66)	%
Age	18 years old	17	25.00
	19 years old	43	65.00
	20 years old	6	10.00
Sex	Female	51	77.00
	Male	15	23.00
SHS Strand	STEM	22	33.00
	Non-STEM	44	67.00

STEM: Science, technology, engineering and mathematics, SHS: Senior high school

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15 (23%) were males. Moreover, the respondents' SHS strand was also included as 22 (33%) took STEM. In comparison, 44 (67%) took other stands, such as Accountancy, business, and management, Humanities and social sciences, and General academic strand.

Research Instruments

Two instruments were used in the study. The first was a demographic profile sheet to obtain profiles such as age, gender, and SHS strand from the respondents. The second tool in the 40-item researcher-constructed "Ecological Knowledge Test" (EcKT) tested the pre-service science teachers' knowledge of ecology and its natural environment implications. The EcKT has three parts, namely, MECs comprising of 20 items; related ecological concepts (RECs) composed of 10 items; and other ecological concepts (OECs) constituting ten items. The EcKT was validated by three environmental science and education experts and pilot-tested with 30 science education graduations. The pilot testing yielded an overall Cronbach's alpha value of 0.759, indicating that the tool was acceptable to be utilized in the study.

Research Procedure and Treatment of Data

The researchers sought approval from the college dean through a letter to conduct the survey. Then, the researchers sought informed consent from the respondents to voluntarily involve in the study. In the beginning, the researchers discussed the nature, purpose, and benefits of conducting the said survey. After which, the 40-item EcKT was administered, taking participants about 30 minutes to complete. The researchers then collected the tests and checked them.

The data were organized and managed in Microsoft Excel and analyzed using the Statistical Package for Social Sciences version 24. Descriptive statistics were used to obtain the mean and standard deviation of the respondents' scores. Inferential statistics was also employed to compare and correlated knowledge variables. The *t*-test for single samples was utilized to determine the level of ecological knowledge in terms of MEC, REC, and OEC. Analysis of variance with conditional Tukey HSD test was further utilized to compare the abovementioned aspects of ecological knowledge. Path analysis was also used to determine the interrelationships within ecological knowledge. Finally, the non-parametric correlational analysis correlated the nominal SHS strand with continuous ecological knowledge variables. All tests were conducted at a 95% confidence level, and any $P < 0.05$ were considered significant.

RESULTS AND DISCUSSIONS

Level of Ecological Knowledge of Pre-service Science Teachers

Ecological knowledge can be divided into three aspects, namely major, related, and OECs (Simmons, 1995; McBride et al., 2013). Table 2 shows the level of ecological knowledge of pre-service science teachers in these aspects.

MECs deal with the individuals, species, population, communities, ecosystem, and biogeochemical cycles. The researchers described the results of MECs as Above Average (μ = 14.14, t = 7.73, P = 0.00). This means that the pre-service science teachers were more knowledgeable about MECs than the general population on average. The major concepts are the fundamental concepts taught to them in their previous educational levels. Fundamental concepts in ecology serve as the basis for understanding the complex biological world (Courchamp et al., 2015). Like the other sciences, the essential pre-requisite knowledge becomes the guide in what learners can do in the next step of the educational ladder (Butler, 2009; Sanchez and Ponce, 2020).

RECs include homeostasis, interdependence, niche, adaptation, and succession. Table 2 demonstrated that the extent of REC knowledge of the pre-service teachers is Above Average (μ = 7.42, t = 5.85, P = 0.00). This analysis found evidence that these pre-service teachers were ecologically knowledgeable. Moreover, they showed interest in such learning areas that drive them to look for ways to get scientific information. According to Spellman et al. (2016), an individual's ability to interpret and apply ecological data in a complex problem increases thinking skills and abilities.

OECs deal with how natural systems work and how social systems interface with the natural system. From the results in Table 2, it is clear that knowledge on other concepts is Above Average (μ = 6.91; t = 5.69, P = 0.00). This implies that the pre-service teachers were ecologically knowledgeable through the application, awareness, and even experiences integrated into their lessons in ecology, other sciences, and related social science disciplines. In line with the previous findings of Ambrose et al. (2010), organizing knowledge influences how one learns and applies what one knows in the natural system. The interface between environment and society (together with the economy) is an essential interaction for sustainability that intermediates action and knowledge of the pre-service teachers (Karpudewan et al., 2013).

Overall, the ecological knowledge of the pre-service science teachers can be described as Above Average knowledge

Table 2: Level of ecological knowledge of pre-service science teachers

Aspect	HM[a]	AM[b]	SD[c]	*t*-value	*P*-value	Description
Major Ecological Concepts	12.00	14.14	2.25	7.73*	0.00	Above Average
Related Ecological Concepts	6.00	7.42	1.98	5.85*	0.00	Above Average
Other Ecological Concepts	6.00	6.91	1.30	5.69*	0.00	Above Average
Overall Ecological Concepts	24.00	28.45	3.95	9.16*	0.00	Above Average

[a]Hypothetical mean set at 60% of the total items, [b]Actual mean derived from the test, [c]Standard deviation of the test scores, *Significant at α=0.05

Science Education International
32(4), 353-357
https://doi.org/10.33828/sei.v32.i4.10

($\mu = 28.45$, $t = 9.16$, $P = 0.00$). With this finding, it is clear that the pre-service science teachers were more than knowledgeable on ecology and related concepts. This may be attributed to the fact that as they were pursuing science education degrees in college, then they must have a good grasp of the ecology and environment around them conforming to the study of Karpudewan e al., 2013; however, Tuncer et al. (2009), Sadik and Sadik (2014) and Mashfufah et al. (2018) only revealed moderate and less knowledge, respectively. Furthermore, having environmental science classes in SHS and at the present college level may also have contributed to the greater extent of ecological knowledge, as found out by Erdogan et al. (2009) and Sadik and Sadik (2014).

Comparison of the Extents among the Aspects of Ecological Knowledge

Table 3 shows the statistical results of comparing the extents of the three aspects (MECs, RECs, and OECs) of ecological knowledge.

Results in Table 3 show that $E(2, 195) = 2.00$; $P = 0.137 > 0.05$, which entails no significant difference among the three aspects of ecological knowledge. This means that the knowledge extent in MECs, RECs, and OECs are comparable. The pre-service science teachers may have encountered these concepts already in their previous educational levels, as evidenced in the present study's Above Average knowledge extents across MECs, RECs, and OECs. Fundamental to this knowledge is the basic concepts in elementary and junior high school ecology and the complex concepts in SHS sciences. Fundamental knowledge is essential in ecology (Courchamp et al., 2015).

Interrelationships in the Ecological Knowledge

The ecological knowledge of the pre-service teachers was further subjected to path analysis to determine how interrelationships of MECs, RECs, and OECs occur within ecological knowledge. These interrelationships are shown in Figure 1.

Based on Figure 1, MECs significantly affect the learning of RECs but not on OECs; this means that fundamental concepts are essential to related concepts but insufficient for other (sustainability) concepts. Courchamp et al. (2015) state that fundamental concepts are essential for understanding the complex biological systems explored in REC concepts such as interdependence and niche. However, Karpudewan et al. (2013) found out that sustainability concepts of pre-service teachers are low, which could explain why MECs do not have a significant effect on OEC. Overall, MECs, RECs, and OECs are significant aspects that could determine pre-service science teachers' level of ecological knowledge. This confirms Simmons's (1995) assertion that these three aspects contribute to the development of ecological knowledge.

Indirect relationships were also analyzed. There was no moderating effect observed on OECs from MECs and RECs

Table 3: Statistical comparison among the three ecological knowledge aspects

Source of variation	SS	df	MS	F-value	*P*-value
Between groups	0.09	2	0.05	2.00^{ns}	0.14
Within groups	4.46	195	0.02		
Total	4.55	197			

^{ns}Not significant at α=0.05

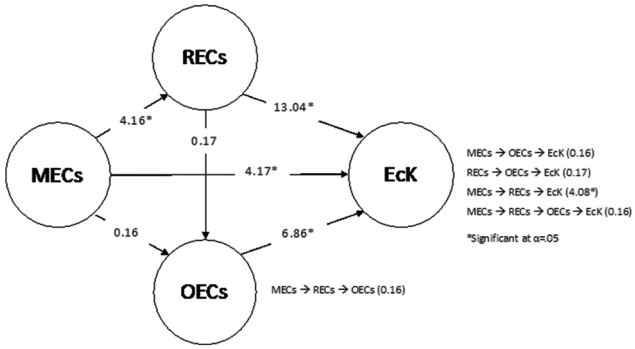

Figure 1: Coefficients in the interrelationships in ecological knowledge

to ecological knowledge, on RECs from MECs to OECs, and on RECs and OECs from MECs, suggesting that OECs and RECs could not mediate the variables to get a significant effect on ecological knowledge. The analysis highlights the significant moderating effect of RECs to get a significant effect on ecological knowledge from MECs. Fundamental concepts, when supplemented by related concepts, yield a positive effect on ecological knowledge.

Ecological Knowledge and SHS Strand

Table 4 shows the relationship between the aspects of ecological knowledge and the strand of pre-service science teachers in SHS.

The analysis of non-parametric correlational analysis found evidence that ecological knowledge and its three aspects have no significant relationship with the strand that the pre-service science teachers took in SHS. This means that ecological knowledge does not necessarily associate with the specific fields these pre-service teachers took in their immediate previous educational level. This finding may be attributed to the exposure of these concepts in the junior high school science curriculum and SHS core subjects (i.e., Earth and Life Science and its STEM equivalent subject), which all these pre-service teachers would have taken. This essential pre-requisite knowledge guides learners in the next step of the educational ladder (Butler, 2009; Sanchez and Ponce, 2020). Ultimately, these pre-service teachers may have pursued Science Education because they had an inherent interest in the subject and showed a willingness to teach it in the future. Interest and perceived need for a future career have been reported as some reasons for pursuing science education at the university level (Palmer et al., 2017).

Science Education International
32(4), 353-357
https://doi.org/10.33828/sei.v32.i4.10

Table 4: Correlational analysis between ecological knowledge and SHS strand

Aspect	Correlation		Symmetry Measure	
	χ^2-value	*P*-value	Cramer's V	*P*-value
Major ecological concepts	0.50^{ns}	0.78	0.09^{ns}	0.78
Related ecological concepts	2.35^{ns}	0.31	0.19^{ns}	0.31
Other ecological concepts	3.63^{ns}	0.16	0.23^{ns}	0.16
Overall ecological knowledge	1.08^{ns}	0.58	0.13^{ns}	0.58

^{ns}Not significant at α=0.05

CONCLUSIONS

The pre-service science teachers in the public university in Central Visayas were ecologically literate, as shown in their Above Average knowledge levels in major, related, and OECs. These three ecological concepts have a significant effect on the overall ecological knowledge of the pre-service teachers. However, their SHS strand did not relate to their levels of ecological knowledge, indicating that they could be ecologically literate regardless of what they pursued in their pre-college education. As future science teachers, they need to be ecologically literate and role models for the students to follow and responsible individuals in the environment.

RECOMMENDATIONS

The researchers identified a range of areas of attention concerning this study. The following recommendations, if taken into considerations, should bring positive changes to the current situations:

1. *Students* shall be continually exposed to the ecological changes and issues for their community through field trips and immersion to increase their awareness and knowledge about the ecology of the Earth. By doing so, they will develop in-depth appreciation and love for the ecosystem.
2. *Teachers*, whether in basic education or tertiary levels, shall emphasize ecological awareness and embed Education for Sustainable Development in the science curriculum. This is to link the environment with society and spreading awareness at the school and immediate community levels.
3. The *community* shall be encouraged to participate in the government's projects geared towards caring for and protecting the ecosystem. In addition, there shall be an enhanced information drive to be participated by the community to strengthen ecological awareness.
4. *Future researchers* should engage in the same study. Changes might be sighted by integrating the problems (how nature affects the human mind and vice-versa), participants (environmentalists, nature activists, or the general public), and more to build harmony on humans and the environment.

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