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Representative research on domain knowledge of students' environmental literacy for 21st Century Competencies Education

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Abstract: In order to investigate the relationship among the students' socio-demographic distribution, different scoring of environmental education objectives and various environmental educational objectives, the research directly quoted the Environmental Education Scale in environmental Literacy for high-level graders in elementary schools designed by Lin & Lin (2010) and Yang (2011), and did the questionnaire survey at an elementary school of Taoyuan District, Taoyuan City, Taiwan in May 2016, withdrew 266 copies of effective questionnaires. We analyzed questionnaire responses, and found that students' socio-demographic background just indicates the significant difference between different grades and whether ever been participated in on- or off-campus associations; nevertheless, students obtain the environment relative information mainly from their families, teachers and school education, and most favorable environmental education methods are outdoor experiential learning, peer discussion and teachers' instruction, etc.; various indicators in different value in environmental education objectives are positive attitude; finally, Pearson correlation coefficient tests that diverse environmental education objectives present significant difference, moreover respectively present low and medium level positive correlations, which could be provided as the reference data to evaluate the teaching process of environmental education curriculum for high-level graders in elementary schools.

Keywords: 21st century competencies education, environmental education, environmental literacy, high-level graders at elementary school

1. Introduction

In most educational contexts Environmental Education is not a compulsory subject. This is because it focuses on topics such as ecological conservation with a goal of influencing the wider public in caring about nature, rationally using natural resources, maintaining ecological balance, and in preventing and avoiding environmental problems. In addition, it has a kind of power which can produce reflection, feedback, propaganda and transfer for the environment (Wang, 2003). The tenet of environmental education is to prompt mankind to acquaint and be deeply concerned about the human and environment relevant problems, so as to make people have ability about environment knowledge, skills, attitude and action, work together to resolve existing environment problem and prevent generating new problems by individual or association (Yang, 1995). Yang (2007) pointed out that the purpose of education is to change human thought and behavior, so the key to resolve environment problems were to develop and promote the educational curriculum which conforms to the goal of environmental education. The Ministry of Education in Taiwan first established the Environmental Education Committee in Nov. 1992 in order to promote environmental education activities in Taiwan. It was accompanied by Executive Yuan's ministries, which have become the key part in school educational content in Taiwan. In order to cope with new trends of globalization, knowledge age and technological development, each country puts forward 21st century competencies education from different angles, in which environmental literacy becomes an emerging field (Shi *et al*., 2016). The ultimate goal of environmental education is to cultivate citizens having environmental literacy, but the development of environmental literacy must follow the principles of environmental education

philosophy and objectives (Wang, 2003; Hsu, 2003; Lu & Hsu, 2011; Srbinovski *et al*., 2010). Regarding the concept of environmental literacy, Sia (1984) indicates that the person bearing responsible environmental behavior is same as the one having environmental literacy; Hungerford & Tomera (1985) considers that environmental literacy has 8 elements, namely ecological concept, environmental sensitivity, locus of control, knowledge of problem, belief, value, attitude and environmental action strategy, etc.; Roth (1992) believes that environmental literacy refers to environment cognition, environment relevant knowledge and attitude holding by individuals, having resolving problem' skills and incentives about environment, and having willingness to proactively maintain a dynamic balance between living and environmental quality. All of that are the core definitions adopted by environmental literacy researchers.

The environmental education implementation is essentially started from school education. About the knowledge contents of environmental education, research done by Frantz & Mayer (2014) and Sutton & Gyuris (2015) indicate that "environmental education teaches the environmental knowledge and experiences, and creates and changes people's belief, attitude and important behavior performance". In environmental education implementation process in Taiwan at present, environmental action practice, experience, examination and reflection about environmental issues are emphasized. But curriculum objectives of environmental education are to trigger the students' consciousness and sensitivities in educational activities, enrich students' relevant knowledge of sustainable environment, make students obtain correct value in the interaction between human and environment, possess improving and solving environmental problems' knowledge and skills when facing daily life and global environmental issues, in order to cultivate students' environmental action experiences, and ultimately objective is to make students have favorable environmental literacy. Furthermore, about research on environmental literacy in Taiwan, Hsu (2001) and Lang *et al*. (2011) showed that learning various environmental issues can promote the environmental literacy of the public and the purpose of environmental education is to cultivate the citizens who have environmental literacy and could adopt responsible environmental behavior. Lu & Hsu (2011) research the visitors' environmental literacy in Jinshan District, New Taipei City, the result reveals that the cognition of environmental literacy relates to recreation purpose, age, educational background, the number of visiting in Jinshan District; the affection of environmental literacy relates to age and the number of visiting in Jinshan District; in the end, the willingness of ecological conservation relates to recreation purpose, means of transportation and average monthly income, of which cognition, willingness, conservation of environmental literacy have positive correlation, but cognition has low correlation with conservation action willingness, which represents promotion of environmental literacy could not only just aim at the cognition dimension, but also enhance the dimension of willingness.

2. Research design and method

2.1 Research design

The research quoted the environmental education scale in environmental literacy for high-level graders in elementary schools designed by Lin & Lin (2010) and Yang (2011). The scale mainly includes two parts: first part is 7 socio-demographic item including gender, which grade students, parents' educational background, parents' occupation, source of environmental information, favorite environmental education methods, whether involved in on or off-campus association, of which parents' educational background, parents' occupation, career type and the most educated parent are check boxes; the second part is 5 environmental education objectives including "Environmental Awareness and Sensitivity", "Conceptual of Environmental Knowledge", "Environmental Ethics and Values", "Skill of Environmental Action" and "Experience of Environmental Action". The high-level graders in elementary schools in Taoyuan District, Taoyuan City are the research object. The grade 5 and grade 6 in the school has 11 classes respectively, average number of students in each class is 28, so the total number of high graders in the school is about 616. In order to make the sample conform to statistical inference, according to the sampling formula of Rea & Parker (1997) calculate that at least 237 student samples could fully reflect the parent population characteristics, the computation formula is as follow:

$$n = \frac{Za^2 \cdot [p(1-p)] \cdot N}{Za^2 \cdot [(1-p)] + (N-1) \cdot C_p^2}$$

"n showed the sample size, *N* showed the parent population, *Za* showed the confidence interval is 95% of the standard normal value (1.96), *Cp* showed the maximum admissible error (5%), *p* showed the parent ratio (0.25)".

2.2 Research method

2.2.1 Socio-demographic background information of high-level graders in an elementary school

Socio-demographic analysis uses descriptive statistics method, aiming at high-level graders' socio-demographic information to conduct frequency distribution statistics, and use Cramer's V value to explain the relationship strength between two categorical variables. In addition, in the socio-demographics of analysis of environmental information sources and favorite environmental education method, check boxes according to liking level in questionnaire design. The research just uses percentage distribution to represent the students' favorite sources of information or education methods.

2.2.2 Significance analysis in five key goals of environmental education

The objective of environmental education is to cultivate the citizen who has good environmental literacy. The research designs the questionnaire through the five key objectives of environmental education, then counts and orders the average values of various items to obtain the cognition degree of high-level graders in elementary school. After that, use one-way ANOVA of dependent samples to discuss. When the analysis results show significant difference ($p < 0.05$), use LSD（Least-Significant Difference）post hoc test to do difference analysis of significance of each item. Of which Conceptual of Environmental Knowledge should utilize choice question model to design the scale, therefore, the statistic results are presented in correct answer rate of various items.

2.2.3 Correlation of various items in environmental education

Analyzing correlation of various items in environmental education is to use Pearson correlation coefficient to test linear relationship in order to test the correlation among various item of environmental education. Of which, Pearson correlation coefficient is between 0~1, there is no or slight correlation when the coefficient is 0~0.25; there is medium level correlation when the coefficient is 0.51~0.75; there is high-level correlation when the coefficient is higher than 0.76 (Portney & Watkins, 2009).

3. Results and discussion

3.1 Socio-demographic background information of high-level graders in an elementary school

The researchers used "stratified random sampling" to select four or five classes in grade 5 and grade 6 as questionnaire samples, and authorized the teachers to distribute and recovery questionnaire in May, 2016. Through questionnaire filing, descriptive statistic results of socio-demographic background information are shown in table 1. First part is gender, female students is more than male in grade 5 and grade 6. In educational background of parents of grade 5, most graduates of senior high schools / higher vocational schools are 60, occupying 40.0%; the minimum of graduates is elementary schools / junior high schools (17 graduates, 11.3%). In educational background of parents of grade 6, most graduates of universities / junior colleges are 51, occupying 44.0%; the minimum of graduates is elementary schools / junior high schools (12 graduates, 10.3%). For parents' occupation, about 47 parents of grade 5 is in service industry, only 5 are soldiers & police and agriculture, forestry, fishery

and animal husbandry; about 35 parents (30.2%) of grade 6 is in service industry, only 3 (2.6%) are soldiers & police and agriculture, forestry, fishery and animal husbandry: other percentages of parents' occupation in different occupation are a little bit different. For the item of whether participated in on- or off-campus association, 57.3% and 80.2% of students in grade 5 and grade 6 respectively did not do before, which are higher than the participators of 42.7% and 19.8%. Moreover, Cramer's V value explains the relationship strength of different socio-demographics; genders in different grades has weak relationship (Cramer's V=0.01), other socio-demographics in different grades show moderate relationship; whether participated in on- or off-campus association (Cramer's V=0.24) ＞ parents' occupation (Cramer's V=0.17) ＞parents' educational background (Cramer's V=0.11). The analytical results indicate that correlation of students' gender in environmental literacy is lowest one, and highest one is the item of whether participated in on- or off-campus association, which could be provided as the reference data to evaluate the teaching process of environmental education curriculum for high-level graders in elementary schools.

Table 1. Socio-demographic distributions of the students in study elementary school.

Socio-demographic	Item	Frequency (n) / percentage (%)				χ^2 (Cramer's V)
		Grade 5	%	Grade 6	%	
Gender	Male	73	48.7	56	48.3	0.01 (0.01)
	Female	77	51.3	60	51.7	
Parents' educational background (the higher)	Elementary school or junior high school	17	11.3	12	10.3	3.20 (0.11)
	Senior high school or vocational school	60	40.0	38	32.8	
	University or junior college	50	33.3	51	44.0	
	Institute and above	23	15.3	15	12.9	
Parent's occupation (the higher)	Soldier or police	5	3.3	3	2.6	7.33 (0.17)
	labor	23	15.3	9	7.8	
	Business	19	12.7	20	17.2	
	Agriculture, forestry, fishery and animal husbandry	5	3.3	3	2.6	
	Civil servant	18	12.0	10	8.6	
	Education personnel	8	5.3	7	6.0	
	Service industry	47	31.3	35	30.2	
	Others	25	16.7	29	25.0	
Whether participated in on- or off-campus association	Participated	64	42.7	23	19.8	15.50*** (0.24)
	Never participated	86		93	8	

Note：1. *** showed $p< 0.001$.

2. Cramer's V value of the scale of the strength of the relationship, in which Cramer's V<0.10 shoewd weaker relationship; 0.10≦Cramer's V＜0.30 showed moderate relationship; Cramer's V≧0.31 showed stronger relationship.

In the part of source acquired environmental related information by students, shown as table 2, highest proportion is 114 from families, occupying 42.9%, then is teachers (22.2%), computer network (10.9) in that order. From the analysis, information sourced from families and teachers occupies 65.1%, which reveals students acquire the environmental information from families and teachers. Besides, for the students' favorite environmental education method, the highest proportion is outdoor experiential learning (36.8%), then, in order, peer discussion (12.4%) and teachers' instruction (12.0%), so most favorable environmental education methods of students are outdoor experiential learning, peer discussion and teachers' instruction.

Table 2. Percentage of students on source of environmental information and favorite environmental education method.

Item	Source of environmental information		Item	Favorite environmental education method	
	Frequency (n)	%		Frequency (n)	%
Family	114	42.9	Outdoor experiential learning	98	36.8
School teachers	59	22.2	Discuss with classmates	33	12.4
Internet	29	10.9	Teacher in class	32	12.0
Television	21	7.9	Visit museum or conservation center	29	10.9
Outside reading	17	6.4	Doing experiments	24	9.0
School textbooks	13	4.9	Internet autonomous learning	23	8.6
Classmates or friends	11	4.1	Watching films or movies	16	6.0
Newspaper	2	0.8	Listening lectures	11	4.1

3.2 Significance analysis in five key goals of environmental education

In order to know the five key goals of environmental education for high-level graders in elementary schools (except dimension of "Conceptual of Environmental Knowledge"), analysis results are show in table 3. The average values of various items are between 3.72 to 4.78, and the total average value is 4.3 which is higher than the options (degree) of "Five-point Likert scale" which indicates that the attitude of students for environmental education goal scale is positive. In the ranking of cognition of various environmental education goals, the scores from high to low are "Environmental Ethics and Values" (4.49), "Environmental Awareness and Sensitivity" (4.31), "Skill of Environmental Action" (4.25) and "Experience of Environmental Action" (4.14). Among them, the average value of "Environmental Ethics and Values" is relatively higher, which presents that high-level graders have better attitude for environment. However, the values of "Skill of Environmental Action" and "Experience of Environmental Action" are lower than other dimension, which present there still has more efforts space in future environmental education in Taiwan.

Table 3. Mean and standard deviation for each item of key goals of environmental education

Key goals of environmental education	Item	Mean	S.D.
Environmental Awareness and Sensitivity	I think using the vehicle with gasoline engine will cause air pollution.	4.56 [a]	0.04
	I know using water and electricity is a good way to save energy and reduce environmental pollution.	4.52 [a]	0.04
	I know we should prepare shopping bags by ourselves which can reduce environmental pollution.	4.52 [a]	0.05
	I know joining in the activity of cleaning the school and neighborhood can improve the environment around us.	4.38 [b]	0.05
	I know our food comes from nature.	4.37 [b]	0.05
	I know the materials making clothes come from nature.	4.09 [c]	0.06
	I can notice the change of natural environment in school.	4.03 [c]	0.05
	I can notice the change of air quality around school.	4.02 [c]	0.06

Note：The same lower-case letters showed that there is no significant difference at the level of 5 %.

Continued table 3. Mean and standard deviation for each item of key goals of environmental education.

Key goals of environmental education	Item	Mean	S.D.
Environmental Ethic and Attitude	We should save water resources.	4.78 [a]	0.03
	I think humans should care for animals and plants equally, not destroying their homes.	4.69 [b]	0.04
	I will feel sympathetic if I see the stray animals abused.	4.59 [c]	0.04
	I can protect land from not being destroyed. (eg. Stop throwing away rubbish randomly.)	4.52 [c]	0.04
	I will respect primitive hunting culture and farming methods	4.45 [cd]	0.05
	I can understand and forgive different cultures.(some people eat meals using hands.)	4.37 [d]	0.05
	I should adopt reusable items (eg. environmental chopsticks and glass)to avoid throwing away after using.	4.33 [de]	0.07
	I am concerned about conditions of surrounding land usage.	4.20 [e]	0.05
Skill of Environmental Action	There are some jobs about trash classification and resource recycling in school.	4.72 [a]	0.03
	I will turn down the volume when I listen to music, because loud music will influence life of neighbors.	4.56 [b]	0.05
	I will turn off the light, electric fan and air conditioner.	4.55 [b]	0.04
	I think bathing in a tub will consume more water than showering.	4.20 [c]	0.07
	When foods are fulfilled in the fridge, this will influence circulation of cold air resulting in wasting electricity and not keeping cold.	4.16 [c]	0.06
	I will report to teachers when water pipes leak water.	4.12 [cd]	0.06
	I found directly using a blow dryer will waste more electricity after finishing washing hair.	3.97 [d]	0.07
	I can notice that there are some faces of animals in school.	3.72 [e]	0.08
Experience of Environmental Action	I will suggest my parents not smoke in public place.	4.53 [a]	0.05
	My family members often notice that the volume of TV, talking to each other is not too loud.	4.38 [b]	0.05
	I will prepare bags or recyclable tableware when shopping or having meals outside.	4.09 [c]	0.06
	I often suggest taking a bus, walking or cycling, not driving cars when going to place that are not far away.	4.09 [c]	0.06
	I am always drinking water instead of buying beverages.	4.04 [c]	0.06
	I suggest families use water again after washing fruits and vegetables.	4.03 [c]	0.07
	I often take the stairs instead of taking the lift.	4.00 [c]	0.07
	I will repeatedly use papers, plastic bags and bottles.	3.99 [c]	0.07

Note：The same lower-case letters showed that there is no significant difference at the level of 5%.

In the end, the dimension is shown in table 4. The items of “Which methods are effective to protect soil below?” and “Which animal is not insect?” got the highest correct answer rate, 98.1% and 89.8% respectively. These two items’ standard answers are “plant more trees; reduce the usage amount of fertilizer” and “spiders”. In the answer of first item, another three options are “disafforest, replant fruit trees and betel palm”, “exploit hilly land to build golf ground”, “heavy use pesticide to kill insect pest”, which are all actions against land conservation; about pest description of the answer of second item, pest belongs to arthropod which body is divided into three parts of head, chest and abdomen, but spider just has cephalothorax and abdomen, so it is not pest.

Table 4. The correct ratio of "Conceptual of Environmental Knowledge".

Key goals of environmental education	Item	Number of correct answer	Correct ratio (%)
Conceptual of Environmental Knowledge	Which methods are effective to protect soil below?	261	98.1
	Which animal is not an insect?	239	89.8
	Which one is not the damage caused by acid rain?	238	89.5
	Which one does not influence living things or the environment when soil is polluted?	226	85.0
	Which one is not air pollution that can cause bad influence for the environment and us?	195	73.3
	Which one is not the influence towards the environment brought on by global warming?	168	63.2
	Which one is not the main growth pattern and conditions of mold below?	119	44.7
	Which part in the structure of plants have the function of making nutrients?	63	23.7

3.3 Correlation of various goals in environmental education

In order to know more about the correlation among various environmental education items (except dimension of "Conceptual of Environmental Knowledge"), as well as the degree of their correlation, the research uses Pearson correlation coefficient to test every items. Among environmental education items, the analysis results all present significant difference, even just positive correlation, shown as table 5. According to the relation screening criterion of Pearson correlation coefficient values, "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", "Skill of Environmental Action" and "Experience of Environmental Action" all present low correlation; "Environmental Ethics and Values" has low positive correlation with "Environmental Awareness and Sensitivity", "Skill of Environmental Action" and "Experience of Environmental Action"; "Skill of Environmental Action" has low positive correlation with "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", and has medium positive correlation with "Experience of Environmental Action"; "Experience of Environmental Action" has low positive correlation with "Environmental Awareness and Sensitivity", "Environmental Ethics and Values", and has medium positive correlation with "Skill of Environmental Action".

Table 5. Pearson correlation coefficient of key goals of environmental education.

Key goals of environmental education	Environmental Awareness and Sensitivity	Environmental Ethic and Attitude	Skill of Environmental Action	Experience of Environmental Action
Environmental Awareness and Sensitivity	-	0.41***	0.50***	0.43***
Environmental Ethic and Attitude	0.41***	-	0.43***	0.43***
Skill of Environmental Action	0.50***	0.43***	-	0.66***
Experience of Environmental Action	0.43***	0.43***	0.66***	-

Note: *** showed that at significant level of 0.001 (two tailed), indicated significant correlation.

4. Conclusion

For students' gender, regardless of whether female or male students in grade 5 or grade 6, their parents educational background and occupation have similar trend, but in subdivisions of items have little bit difference; for the item of whether participated in on- or off-campus association, get more students never participated association than participated. Furthermore, students' gender has the lowest

correlation with their socio-demographics in Cramer's V, but has the highest correlation with the item of whether participated in on- or off-campus association. For the significance analysis of five key goals of environmental education, the analysis of students' environmental education objectives (except dimension of "Conceptual of Environmental Knowledge") got the value 4.30 which is higher than the options (degree) of five-point Likert scale, which situation indicates that the attitude of students for environmental education goal scale is positive. In the ranking of cognition of various environmental education goals, the scores from high to low are "Environmental Ethics and Values", "Environmental Awareness and Sensitivity", "Skill of Environmental Action" and "Experience of Environmental Action". At last, utilize Pearson correlation coefficient to test the result of environmental education goals. Among different environmental education goals, statistical results present significant difference even is low to medium positive correlation.

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References

Frantz, C. M., & Mayer, F. S. (2014). The importance of connection to nature in assessing environmental education programs. *Studies in Educational Evaluation, 41*, 85-89.

Hsu, S. J. (2001). Can we educate citizens who can solve environmental problems? On environmental education and environmental action. *secondary education, 52*(2), 52-75.

Hsu, S. J. (2003). Significant Life Experiences Affecting the Environmental Action of Active Members of Environmental Organizations in the Hualien Area. *Chinese Journal of Science Education, 11*(2), 121-139.

Hungerford, H., & Tomera, A. (1985). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education, 18*(2), 1-8.

Lang, Y. C., Lei, W. G., & Chang, S. Y. (2011). Study on the relationship among environmental literacy, environmental attitude and conservation behavior of ecotourism tourists. *NCYU Physical Education, Health & Recreation Journal*, 10(3), 23-36.

Lin, S. H., & Lin, M. R. (2010). *Study on the environmental literacy of teachers and students in elementary and junior high schools in 2010*. Ministry of Education (environmental group), Program number: 99-0105445.

Lu, T. H., & Hsu, C. S. (2011). An Assessment of Environmental Literacy of the Tourists in Jinshan. *Journal of Tourism and Health Science, 10*(1), 131-146.

Portney, L., & Watkins, M. P. (2009). *Foundations of clinical research: Applications to practice (3rd Edition)*. US: Pearson/Prentice Hall.

Rea, L., & Parker, R. (1997). *Designing and Conducting Survey Research– A Comprehensive Guide*. San Francisco: Jossey-Bass Publishers.

Roth, C. E. (1992). *Environmental literacy its roots, evolution and directions in the 1990s*. Columbus, Ohio: ERIC/ CSMEE.

Shi, M., Liu, S., Liu, X., Zhou, P. Y. Chen, Y. Y. Liu, J., & Wei, R. (2016). Research on the framework and elements of 21st Century Competencies Education. *Journal of East China Normal University (Educational Sciences),*3, 9-37.

Sia, A. P. (1984). *An investigation of selected predictors of overt responsible environmental behavior*. Unpublished doctoral dissertation, Southern Illinois University at Carbondale.

Srbinovski, M., Mehmet, E.,& Ismaili,M.(2010). Environmental literacy in the science education curriculum in Macedonia and Turkey, Procedia - Social and Behavioral Sciences, 2(2),4528–4532.

Erdogan M., & Ismaili, M., et al. (2010). Environmental literacy in the science education curriculum in Macedonia and Turkey. *Procedia-Social and Behavioral Sciences, 2*(2), 4528-4532.

Sutton, S. G., & Gyuris, E. (2015). Optimizing the environmental attitudes inventory: Establishing a baseline of change in students' attitudes. *International Journal of Sustainability in Higher Education, 16*(1), 16-33.

Wang, C. M. (2003). Ecological Foundation and Concepts for Environmental Education. *Chinese Journal of Environmental Education, 2*, 9-46.

Yang, C. C. (2011). *Establishment of Environmental Literacy Indicators and Scale for The Fifth and Sixth Graders*. Master Thesis, Master Program of Environment Education and Management, National Taichung University of Education.

Yang, G. Z. (1995). The history of environmental education. *Bulletin of Educational Resources and Research, 20*, 1-33.

Yang, G. Z. (2007). *Environmental Education*. Taipei City, Taiwan: Ming-Wen Bookstore Co., Ltd..