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Environmental Mental Models of Science Educators: A Multiple Case Study of LET Topnotchers

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Abstract: *This study used the multiple case method to look into millennial science educators' present environmental mental models, the pedagogical challenges faced when teaching environmental education, and their environmental attitudes. Six in-service secondary science teachers were chosen for an intensive study of their environmental mental models based on the following criteria: they must be a topnotcher in the licensure exam for teachers (LET), be a recent graduate of a Bachelor's degree in Secondary Education with a science major, and be a graduate of a Teacher Education Institution recognized as a Center of Excellence by the Commission on Higher Education. The following mechanisms were used to achieve the research objectives:Draw-An-Environment Task and Pick-A-Photograph Task, and an interview guide for IDI. All interview sessions and tasks were done via Google Meet video conferencing technology. The tasks were analyzed using the Environment Mental Model Typology and DAET Rubric, while thematic analysis was applied for the interview data. Findings reveal that millennial science educators' predominant EMMs view the environment as a place that supports life and a place that is impacted by man. Their understanding of the environment remained basic, reflecting a lack of a systems perspective on the interaction dynamics of the environment.*

Keywords: *environmental education, environmental mental model, multiplecase study, typology, DAET-R, Philippines*

1. INTRODUCTION

Research in the field of environmental education have mostly focused on exploring and understanding students' attitude, behavior, and factual knowledge [1-2]. Lesser attention has been hovered over environmental mental models (EMM) which arguably dictates how people behave towards the environment and how they understand environmental issues [1,3]. Previous studies were made concerning EMM however, the subjects were either students [1,3-6] or pre-service teachers [2,7,8].

Based on the studies conducted, it has revealed two consistent problems: 1) humans were not considered part of the environment, and 2) environment is not seen in systems approach thereby having an incomplete understanding of it [1-2,6,8]. With this, it was proposed in 2015 [4] the need for experiential learning after observing a significant improvement on her participants' post-fieldtrip EMM. In 2017 [3], on the other hand, have seen the positive effect to the participants' EMM after introducing environmental conservation course.

It was noted that in 2007 [1] that students' conceptualization of the environment serves as a pre-requisite for understanding environmental issues. On the other hand, it was stressed out in 2010 [7] that pre-service teachers will not be able to teach their students properly about the environment if they have an incomplete EMM because this will influence their pedagogy. This has been further supported in 2017 [9] that having a correct conceptual understanding of the environment will not only help in identifying environmental problems but will also aid in providing solutions and assuming environmental responsibility.

While previous literatures presented the EMM of students in basic education, college level, and even pre-service elementary teachers, as well as its connection and importance towards developing environmental awareness and behavior, understanding environmental problems, and effect towards

environmental education (EE), no known study has explored the in-service secondary science teachers' EMM. Since it was claimed that being able to determine EMM will contribute to effective EE [10] and help the EE curriculum makers [5], the researcher in this study perceived the need to determine the EMMs of topnotch secondary science educators in the Philippines because they are the ones already deployed in the field and responsible for the education of the current generation. More specifically because the schools in the country consider these topnotchers as great deal in providing quality education. Furthermore, in the Philippines, there is only one known study about mental models but none for environmental mental models. It was the research in 2012 [11] entitled "college students' individual and group mental models of electrostatic force". Therefore, the researcher aims to look closely on this aspect being a LET topnotcher and science educator herself.

2. Materials And Methods

A multicase study was used to better understand and investigate the topic. Six cases were explored in accordance with the guidelines set in 2013 [12] for doing a case study. Moreover, purposive sampling was carried out to ascertain that the participants can tenaciously provide information about the research topic [12]. To carefully select the participants, inclusion criteria was set. This includes 1) secondary science teachers, 2) LET topnotchers, and 3) University of Mindanao (UM) alumni. The said institution was chosen as research site because among all the Teacher Education Institutions in Region XI with Center of Excellence status, UM has been hailed as the home of LET topnotchers. The research questions in this study are:

1. What mental models do topnotch science educators have about the environment?

2.What challenges were experienced by topnotch science educators in their pedagogical approach in environmental education based on their mental models?

3.How do the environmental mental models of topnotch science educators shape their attitude towards the environment and ecological concerns?

In addressing the research question 1, Environments Task was presented to the participant. This includes Draw-An-Environment-Test (DAET) and Pick-A-Photograph. Environments Task was developed in 2007 [1] and was adapted in 2010 [2]. For DAET, the respondents were instructed to add labels in the drawing and provide a short explanation below it. On the other hand, the Pick-A-Photograph which was adapted in 2017 [3]was modified by the researcher in this study to depict Philippine environment. The photographs include: 1) undisturbed tropical rainforest, 2) view of an agricultural land, 3) residential development, 4) waterpark with no presence of any non-human life, 5) sand dunes, 6) carabaos in water environment, and 7) commercial development. In this part, the participant was told to identify and justify which among the photographs depicts an environment.

DAET-Rwhich was developed in 2010 [2] was used to interpret their understanding of the environment by assigning scores ranging from 0-3. The focus was on the environmental factors: 1) humans, 2) other biotic organisms, 3) abiotic organisms or physical environment, and 4) built environment. For a factor to get a score, it must be present in the drawing. The scoreranges from 0-12, wherein a high score indicates the completeness of their understanding about the interactions present in the environment. Afterwards, each drawing was categorized into MM typologiesidentified in 2007 [1] : 1) the environment is a place where animals/plants live- a natural place, 2) the environment is a place that supports life, 3) the environment is a place impacted or modified by human activity, and 4) the environment is a place where animals, plants, and humans live. To concretize their views about the environment, drawings were cross-referenced with their answers in pick-a-photograph.

For research questions 2 and 3, guide questions were used. The participant was first probed about the pedagogical approach/es and challenge/s in handling environmental education. Then followed by interview questions for environmental attitudes. These were formulated by the researcher based on Environmental Attitudes Questionnaire (EAQ)developed in 2015 [13]. Thematic analysis was carried right after the interview.

3. RESULTS AND DISCUSSION

Environmental Mental Models of Topnotch Science Educators

It was found out that the participants did not possess complete understanding of the environment. This is consistent with the previously conducted studies about pre-service teachers having incomplete EMM [2,6-8,10].A complete understanding must be equal to 12 points, unfortunately their scores only range from four to seven with a mean score of five. Therefore, the participants fully understand that environment is composed of biotic and abiotic factors, as well as the existence of interaction between living and nonliving, but they lack the understanding of a system approach. In a system approach, one factor must be seen interacting with more than one factor, and there is an explicit depiction of its interaction's impact to the environment. A multifaceted cycle of interaction among humans, other biotic factors, abiotic factor, and designed or built environment.On the positive side, majority of the participants included humans as part of the environment which is in contrast to the results previously reported [1,6,10].

Moreover, three out of six participants have a specific MM while the other three have an integrated type. Lala and Riri possesses EMM 4, as depicted in figures 1B and 1D, which shows the presence of humans, plants, and animals living peacefully in a natural setting without any presence of built environment, while Veve has the EMM 2, shown in figure 1E, which generally provides needed resources for the animals, humans, and plants to live. Mimi and Lenlen's EMM (figures 1A and 1F) are made up of the categories both belonging to MM 2 and 3. In the said figures, the environment was primarily depicted as a place which was needed by every living being to survive (EMM 2) however, the presence of pollution and designed or built environment such as buildings (EMM 3), were also included. Rara's EMM (figure 1C), on the other hand, is made up of the categories belonging to MM 1, 2, and 3. This was considered the most distinct illustration during the data collection. The environment presented in his drawing does not contain humans (EMM1), nor animals. It only showed potted plants freely benefitting from its surrounding (EMM2) and energy coming from the rays of the sun (EMM 1) which passed through a widely built window, in this study it is classified as a designed environment (EMM 3).

Generally, the participants consider two concepts about the environment: rural and urban. The test Pick-A-Photograph further proved this claim where the participants have chosen the pictures containing both greens and urban representations. Hence, it can be noted that their responses are geared towards the sustainable development where they have clearly shown the importance of green spaces and plants thriving despite the modifications done by human beings to the natural setting.

Challenges Experienced by Topnotch Science Educators in their Pedagogical Approach

Based on the qualitative analysis done for IDI responses in RQ 2, it led to the emergence of three themes namely: exploratory hands-on experience, emergent approach to teaching, and health and classroom restrictions. The said themes reflect the challenges perceived by the in-service secondary science teachers in their chosen pedagogies as affected by their EMMs.

Exploratory Hands-on Experience. This theme contains the kind of teaching pedagogies that the participants wanted to employ when tasked to handle environmental education. Their answers commonly include the need for the students to be exposed, discover, and construct their own learning, either by way of being brought to the field or at least see pictures and videos which serve as representations of the environment. Nevertheless, majority favored the use of experiential learning while minority favors the use of reflective practice since they consider it impossible to bring the students to the environment. Those who favors reflective practice shared that they teach environmental education by showing pictures and videos that shows what is happening in the real world and requiring the students to collaboratively create infographics or posters about the environment.

Mimi, a 23-year-old college instructor who have not taught environmental education yet and wasn't able to experience doing fieldwork during her student life, enthusiastically shared how she would deliver the said subject to her students in the future.While sharing her preferred teaching pedagogy, Mimi was more than convinced with the idea that her students are not empty slates.She believes that they carry interesting ideas with them hence, as a teacher, she does not want to do all the talking and would rather let the students experience then share whatever it is that they have learned. Veve, on the

other hand, a 23-year-old teacher who is currently pursuing his master's degree and was able to handle environmental education recalled how he used to teach EE to his previous students.

Altogether, this result supports the proposition in 2015 [4]. She vividly recommended that the use of experiential learning cycle in teaching environmental education would help the students understand

the concept of environment and give them a clearer view of it. The said cycle included four steps: 1) active experimentation, 2) concrete experiences, 3) reflective observation, and 4) abstract conceptualization.

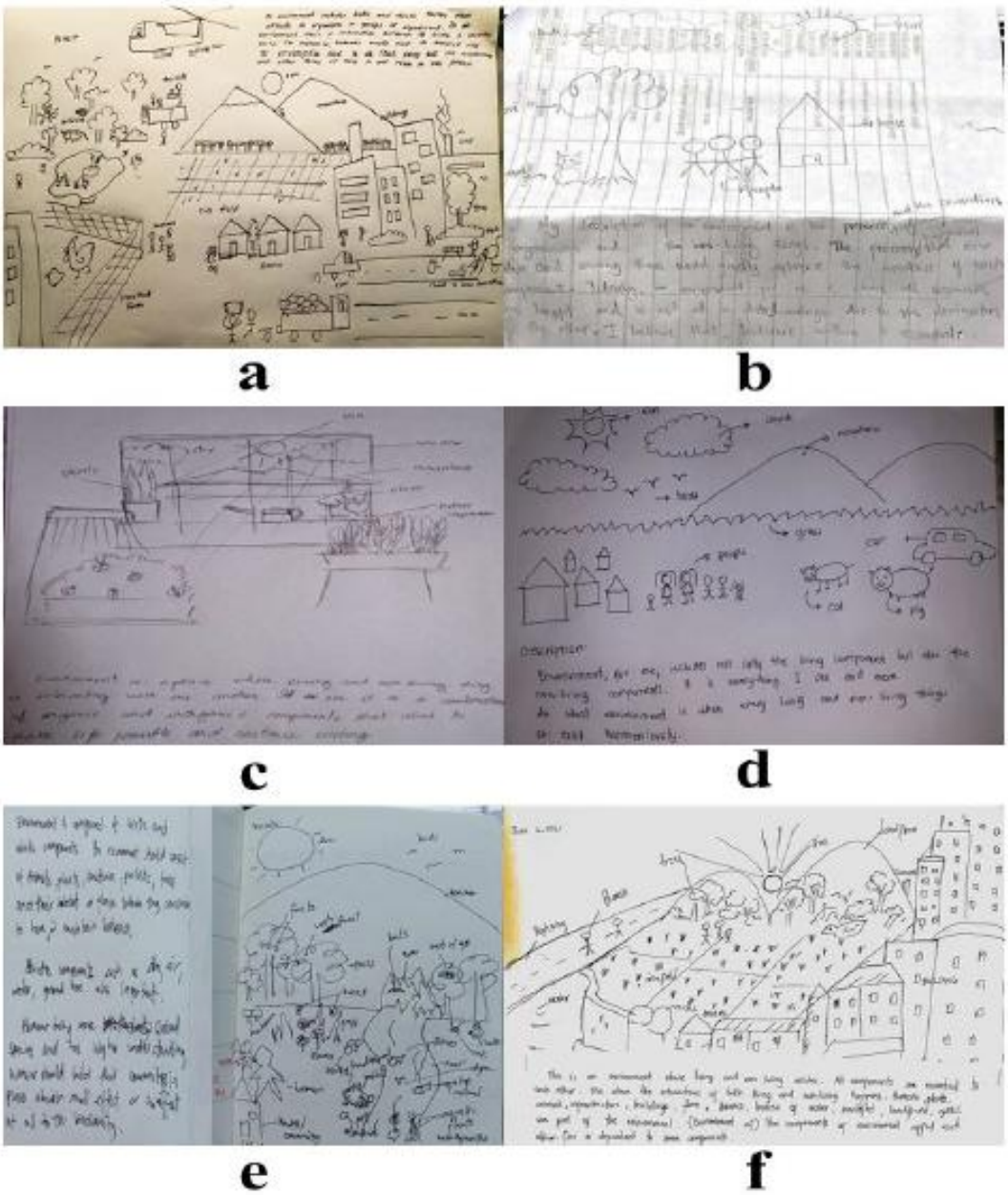
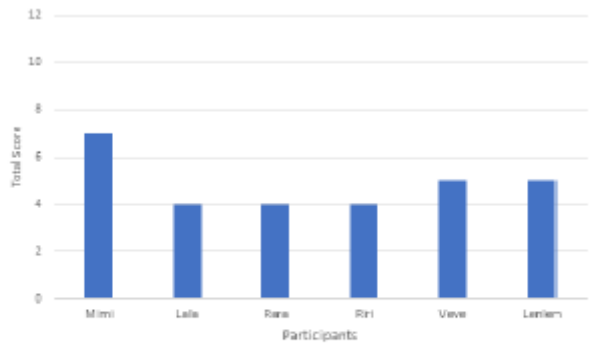


Figure1.*Participants' DAET: a) Mimi's DAET, b) Lala's DAET, c) Rara's DAET, d) Riri's DAET, e) Veve's DAET, and f) Lenlen's DAET.*

Emergent Approach to Teaching. All the challenges perceived by the participants in teaching environmental education are contained within this theme. This includes the students' misconceptions about the environment, overrated environmental issues, and the feasibility of implementing their chosen pedagogical approach. In connection to their EMMs, those who included humans in their drawings were the ones who wanted to either expose their students to the environment or take an active part by planning and creating infographics for the environment. They also consider feasibility, implementation, safety, and security as challenges in teaching environmental education because

hazards or disasters may happen at any moment since factors other than humans are also present in the environment. Whereas for Rara, who only drew plants inside a built environment does not consider feasibility, hazards, or disasters as a challenge in doing experiential learning because for him, gardens or backyards are already a good example of an environment. The only challenge that he considers is his learners' misconception towards the environment.



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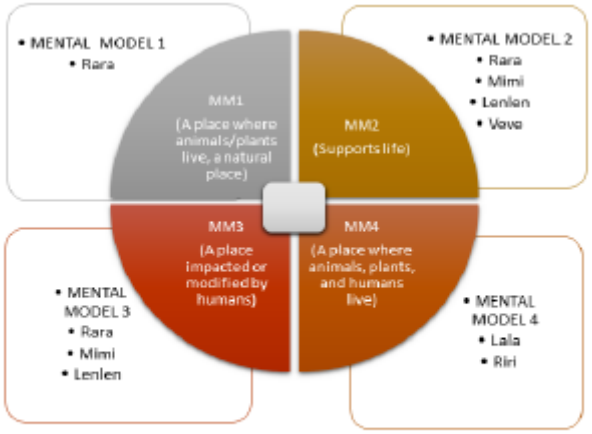

b

Figure2.*Interpretation of Environments Task: a) Participants' Understanding of Environment (0-12), and b) Participants' Environmental Mental Model Categorization*

This further proves the mental model theory [14] as well as the propositions of in 2014 [15] andin 2015 [8]. According to the said authors, mental model is known as directly affecting people's beliefs, ideas, reasons, and decisions. It is evident in the current study that those who see an environment as a place with wildlife, forests, built environment, and other living and nonliving components are more afraid of bringing their students to the field. They tend to think about sudden disasters or hazards that might put their lives at risk hence, they find it hard to implement their chosen approaches.

Health and Classroom Restrictions. This theme contains the specific impact of the participants' EMM to their chosen teaching pedagogy and difficulties or challenges in handling EE. Safety and security, permits, and pandemic were among the common answers raised by the participants.However, aside from their own perceived challenges, they also claimed that their preferred approach is at times hindered by due diligence permits, online mode of classes, and other environmental and pandemic concerns.

Ririviews the environment as a place where both living and nonliving things exist harmoniously, stated that her EMM really affects.Furthermore, Lenlen who views the environment as a place comprised of the virgin forests and built environment and teaches EE by requiring his students to come up with a plan and infographics about the environment, also conceded that his EMM creates a great effect.

While the themes mentioned above were all in parallel of the previous studies conducted, this theme presents an additional input. Aside from their EMMs, there are still other factors or concerns that causes direct impact to their actions and decisions. With all the issues and concerns arising nowadays, as science educators, they ought not to be ruled by their EMMs alone. Therefore, this result suggests that EMMs influence their pedagogy [2] but it can at times be controlled when an external force outweighs the concerns brought about by their EMMs.

In summary of the themes presented, it shows that the participants' pedagogical approaches and challenges in handling EE is indeed being affected by their existing EMMs. For those who included humans in their drawings, they expressed the need for the students to experience, see representations and take part in the environment. They also consider feasibility, and hazards as challenges in teaching EE. While for Rara, whose EMM only contains plants inside a built environment which resembles a greenhouse, emphasized the need for the students to be exposed to the environment, and the only challenge that he considers is students' misconception. He further added that it's easy to expose the students because gardens or backyards are already a good example of it.

Environmental Mental Models in terms of Shaping Topnotch Science Educators' Environmental Attitude

After conducting qualitative analysis for the participants' answers in RQ 3, there were a total of eight themes recorded. This includes nurture a caring attitude for the environment, desire for sustainable development, culpability due to anthropological activities, bureaucracy of environmental laws, remorse on environment's fate, publicize environmental issues, practice 3 R's (reduce, reuse, recycle), and limit human footprints.

Nurture Students' Care for the Environment. As science teachers, they all share the desire to take good care of the environment. Some would like to achieve this by spreading awareness and educate their learners, while others became fascinated with taking good care of plants. Nevertheless, their goal all boils down to showing respect for biodiversity. Mimi fondly shared that in her EMM, she pointed out the interactions of biotic and abiotic factors. Hence, every time an opportunity arises, she grabs it right away to help educate the learners about the environment. She wanted to teach them how to take good care of the environment because it does not only include cities and buildings but also wildlife. Similarly, Lala, who drew group people holding each other's hand, also acknowledged the need to take good care of the environment while emphasizing the great responsibility of humans because they carry a certain intellectual capacity which enables them to decide what and what not to do. She stated that in doing so, even little things or actions really matter. Rara, on the other hand, claimed that his EMM was really a reflection of him because of his great fascination for plants. As a matter of fact, he considers plants as his pets. Moreover, he also envisions that their house will eventually turn out like that of his drawing.

This goes to show that the proposition in 2007 [1] and in 2017 [9] about EMM still holds true at present. According to him, proper understanding of the environment is necessary to have correct understanding of different environmental issues. It was reported in the result section that the participants carry with them a basic understanding of the environment, hence this enabled them to develop the above listed environmental attitudes.

Desire for Sustainable Development. With all the environmental issues arising nowadays, including environmental degradation and biodiversity loss, the participants have raised their own sentiments as to how it affected them in various ways. It was altogether a mixture of different feeling and opinion such as stress, guilt, compromise, alarmed. Riri shared that after graduating from her bachelor's degree, she really came to appreciate environment even more. Therefore, she feels sad every time she sees negative news about it. She also wanted to help the environment recover in any way she could. Veve, on the other hand, feels guilty about the existing environmental issues. He said he is aware that problems such as depletion of trees or even extinction of species will create a great impact towards the environment and to himself. However, despite this he still at times forget to practice pro-environmental actions. Whereas Lenlen simply admitted that everything that's happening today is indeed very alarming. He also added that he feels threatened because these problems will eventually worsen in the future.

This theme is in support of the claim that being able to understand the environment, will also enable the person to think or come up of better solutions for the environment [9]. With the rapid rate of industrialization, the participants see the need to compromise and meet halfway. They are eyeing on sustainable development as the only solution to make both ends meet since people can no longer live without the developments that they have enjoyed in the past years.

Culpability due to Anthropological Activities. The participants were asked about how they feel towards human activity, plant life, and animal life, and as a result, they all pointed towards the superiority of humans over the other components. They also stressed out how human activities went overboard and its effect to flora and fauna. Mimi is personally convinced that humans will never survive without the nature because it serves as the provider of everything that humans need such as the air that we need for breathing. While nature, on the other hand, will continue to exist and flourish even without humans. Hence, she believes that anthropological factors are to blame for the existence of environmental problems. Similarly, Lala also agrees that human activities have went overboard. She even added that it is part of human nature to consistently want to have more but she sees no point to it because the things that we acquire will all be left behind once we die.

This theme means that the participants were able to identify the reason behind the problems that have existed in the environment. It, therefore, supports the statement that EMMs help an individual identify and recognize environmental problems [1,9]. With the problems arising, the participants managed to trace the roots which lead them into conclusion that humans are still held responsible.

Dismay over Bureaucracy of Environmental Laws. Regarding the government's action towards the existing environmental problems, the participants surprisingly commented that even though laws are already existing, these are still not enough. They raised the idea that it needs strength and more collaborative effort to successfully implement the said laws. As a matter of fact, Veve used this as an opportunity to personally raise his concern about putting rightful people in government offices. He said it is important to put officials like the late Gina Lopez in position because they have the eagerness to go extra mile in saving the environment. Subsequently, Riri thinks that the implemented laws and ordinance are not strong enough. She even used their community as point of reference because according to her, she still sees improper waste disposal which leads to clogging of their drainage system. However, she still hopes that the government would take necessary actions and strengthen their fight against these problems.

Moreover, the participants raised the necessity to strengthen and embed environmental education in the current curriculum as it is deemed to help in the development of the students' understanding of the environment. This is in support to the statement in 2017 [9] about the importance of environmental education. Exposing the students to the concept of environment starting from their younger years will help them understand the issues, problems, and responsibilities that we have towards the environment. It was also claimed that through EE, the governments will be able to create substantial and effective laws to protect the environment.

Remorse on Environment's Fate. A futuristic question was raised about the possible death of the world within 40 years if we will not remake the environment. Significant answers from the participants include feeling fearful, devastated, alarmed, and worried. The will to help lessen human impact also surfaced. Lala mentioned that she feels sad thinking about it but above all else, she fears about the future of her children and her children's children. She supposedly wanted them to experience the beauty of nature as she was able to experience it before but considering the problems that we have today she thinks it is no longer possible. Rara also admits that it is alarming but at the same time, it is a fact that one should always remember. According to him, if we are to take a look in our way of living, and how we manage our wastes, it is really not impossible that the earth's existence will be threatened. Hence, we must help by creating our own little change. In the same manner, Lenlen also agrees that it is inevitable, and we can never stop it from happening. However, we can somehow lessen or at least delay it. Considering that the earth is capable of healing itself, maybe we can help it in some ways like proper regulation of waste, pollution, carbon dioxide emission, and others.

Therefore, they are more than convinced that while it is not yet happening, they can somehow help lessen the problems by taking necessary actions. It agrees with the idea that if humans are included in the DAET, there is a higher chance that the participants will be able to feel for the environment [1].

Since it was seen in figure 1 that majority if their drawings included humans, it is safe to conclude that it is the reason why they feel remorse over the fate of the environment and is willing to take actions.

Publicize Environmental Issues. In the light of the existing environmental problems, the participants expressed their desire to use their profession in spreading awareness. They somehow believe that the lay people lack proper understanding about these things hence, the participants are looking forward to using their influence as teachers. Moreover, all six of them conveyed their willingness to help when opportunity arises. Lala jokingly uttered that it is no longer a question for a science teacher like her. She said she is very much willing to take personal steps and participate in the call to help the environment. She also believes that as a teacher herself, she has this certain degree of influence and that it is part of her moral obligation to share to the young people whatever knowledge she possesses. In parallel to Lala's statement, Lenlen also considers it as a mission for the teachers. He personally thinks that it is necessary to spread awareness about the environmental condition through providing education to the students.

In contrast, [1] stated that though it is important for students to become aware of the environmental issues, the emphasis in environmental education must first be placed on the development of correct environmental concept while slowly incorporating the issues that we have at present. Furthermore, it was also posed that if possible, the local environment will be used for the introductory phase of environmental education before enlarging to environments around the globe.

Practice 3 R's (Reduce, Reuse, Recycle). Generally, the personal steps or initiatives that each participant have done so far includes but are not limited to waste segregation, conservation of household's basic needs, creating green spaces at home, recycling, and the like. In the case of Rara, he claims to support environmental care as well as sustainability by creating green spaces at home. He also makes sure that whenever he buys plants, it should be the propagated ones not those coming from the wild. Additionally, Riri sees to it that she lessens her use of plastic to avoid adding up to the current number of wastes or garbage. In some cases where using of plastic won't be avoided, she would use it over and over again until it is no longer useable.

The personal actions mentioned above is in connection with the theme mentioned earlier, the culpability of anthropological actions. The participants believed that environmental issues were results of human activities and that humans ought to be responsible for it. They seem to develop a set of positive behavior and action towards the environment because of their belief that humans are to be held responsible. This further supports the claim of [16], that standards of behavior will emerge once a person thinks that bearing responsibility means acting, and not going against it as this will produce negative effects.

Limit Human Footprints. In terms of the possibility of discovering an undiscovered or untouched natural resources, such as waterfall, the common trend in their answers is to protect the nature from people and the harm that they may cause. They, however, differ in ways of protecting the environment because some wants to completely shut it from human entry, while there are also some who would allow tourists to come but with strict regulations. Nevertheless, the point and goal remain- protection. Mimi was full of conviction when she raised her point about the total ban of people from entering. She detests the idea of converting it into a tourist spot because, according to her, there are lots of tourist spots that were now depleted due to negligence. In contrast, Veve would like to make it a nature park or a protected landscape. This will be used as a place where students or ordinary tourists will be educated upon their visit.

The said theme clearly supports the fight for sustainable development. In using the earth's natural resources, it is needed to consider the future generations. It was mentioned by [16] that humans of present generation must learn to use the resources sustainably and not to exploit it nor damage is, thus playing an important role in the preservation of environment.

To sum it up, this theme discusses about the direct influence of the participant's EMM towards their environmental attitude. Based on the results presented, it can be noted that their EMM made them elicit pro-environmental decisions, actions, and attitude. However, since they still have a basic understanding of environment, as reflected in their scores in DAET-R, their environmental affect and behavior also remained basic. Like how they focused on pushing 3 R's and recognizing the need to spread awareness. No one was able to raise the idea of protecting a certain species because it's extinction would boomerang to the survival of other species, nor seeing the interconnection and

interdependence of one component to another. Nevertheless, they already possess a promising knowledge about the environment and how to help protect it.This result is still in parallel to the literatures previously conducted about how mental models influence an individual [8,14-15].

4. CONCLUSION

The EMMs of topnotch millennial science educators included humans, other biotic factors (plants and animals), abiotic factors (sun, clouds, and mountains), and designed or built environment (car, buildings, and highways). This signifies their desire for a more sustainable development where certain degree of compromises are made for the sake of the natural ecosystem to continually thrive despite the increasing rate of urbanization. Although their understanding of the environment ends with the one-way interaction of one factor to another, their environmental attitude and knowledge is already very promising. They can feel remorse on environment's fate and have a wishful thinking about ending the bureaucracy on environmental laws. Moreover, since they consider humans as part of the environment itself, their willingness to take part in the fight against global warming, depletion of ecosystem, and other issues is dependable. As science educators, they also see the urgent need to spread awareness and educate the people about our environment. They are more than convinced that they can use their influence and power to help eradicate environmental problems.

With all the findings presented above, the researcher in this study concludes that environmental mental models play a vital role in the attainment of success in environmental education. This study shows that pedagogical approaches and environmental attitudes are influenced by one's EMM. Therefore, it is of utmost importance to ensure that everyone gets the right view about the environment, especially teachers. It is already very promising that the topnotch millennial science educators foster a good understanding of the environment, but it would be best if they will be able to develop a complete understanding of the environment to better understand how domino effect happens in the environment. However, the kind of science curriculum plays a vital role in achieving this goal. It was noted in this study that experiential learning helps in building a complete understanding and correct view of the environment, but the in-service teachers are hindered from applying the said approach because it is not supported by the present curriculum. With this, the author sees the need to transform the science curriculum in the country and include more environmental exposure by embracing various activities such as citizen science, fieldworks, and the like.

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