

## Article

# Global Citizenship Competencies of Filipino Students: Using Machine Learning to Explore the Structure of Cognitive, Affective, and Behavioral Competencies in the 2019 Southeast Asia Primary Learning Metrics

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**Abstract:** While the Philippines is still building its global citizenship curriculum, there are global citizenship competencies already articulated in existing curriculum guides. Using data from a nationally representative sample of Grade 5 students in the Southeast Asia Primary Learning Metrics (SEA-PLM) assessment, we explored Filipino learners' current global competencies. We used machine learning approaches to determine the best models to predict the six SEA-PLM global competency indices; models generated by Multilayer Perceptrons performed better than other techniques. Shapley Additive Explanations approach was applied to identify variables that had the most impact on the model of each global competency index. Some variables were important predictors across the indices: concern about pollution, feeling connected to people from other countries, beliefs about the importance of learning about other countries, how countries relate to each other, and how natural disasters in other countries affect the Philippines are variables that were associated with global competency indices. Willingness to participate in classroom debates also positively predicted the indices but willingness to participate in classroom elections negatively predicted indices related to knowledge and behavior intention indices. We discuss how patterns in Filipino students' emerging global competencies can guide curriculum development.

**Keywords:** global citizenship education; global competencies; education for sustainable development; Southeast Asia Primary Learning Metrics; Philippines; machine learning; global citizenship

## 1. Introduction

As the world becomes increasingly globalized, many countries have started paying attention to the need to develop competencies that will allow their citizenship to effectively engage and function in a globally interconnected and intercultural world. The construct of global competencies has become the focus of discussions on global citizenship education in many parts of the world after the United Nations launched the Global Education First Initiative in 2012 [1] and UNESCO included global citizenship education (henceforth, GCED) as one of the strategic priorities in its programs for 2014–2021 [2]. However, many countries, including the Philippines, have not yet officially adopted curricular frameworks for GCED and are still in the process of studying and defining the pertinent definitions and frameworks for GCED that is best suited for the educational goals of their respective educational systems. In the Philippines, there are current initiatives to understand how global competencies are articulated in existing curricula [3], and

these studies indicate that there are global citizenship competencies included in the current social studies and values education curriculum guides. Given that some global citizenship competencies are already said to be articulated in the current curriculum, we explored the existing knowledge, beliefs, and behavioral intentions of Filipino primary school students. We used machine learning approaches to analyze global citizenship data from Filipino Grade 5 students who participated in the Southeast Asia Primary Learning Metrics (SEA-PLM) assessment. In particular, we explored how Filipino students' knowledge, attitudes, beliefs, behavioral intentions, and other experiences relate to their global citizenship competencies in the six domains measured in the SEA-PLM.

### *1.1. Global Push for Global Citizenship Education*

The lives of people in different countries have become increasingly interconnected because of increased migration, intensified integration of economic markets, and different forms of connections afforded by information and communication technologies. There is also an acknowledgement that the most important problems human beings face (e.g., climate change, pandemics, socioeconomic inequalities) can be addressed only by cooperation of peoples from all countries across the globe. Amid these developments, GCED has been conceptualized to embody the education of students in the shared values, knowledge, and habits of thinking that are needed for effective participation in a globalized world.

Following the inclusion of GCED as one of the strategic priorities of UNESCO [2], the Declaration for Education 2030 was launched at the World Education Forum 2015 [4]. The declaration defined quality education as that which “also develops the skills, values and attitudes that enable citizens to lead healthy and fulfilled lives, make informed decisions, and respond to local and global challenges through education for sustainable development (ESD) and global citizenship education (GCED)”. This definition of quality education is anchored on a renewed emphasis on the role of education for human development, economic, social, and environmental sustainability, and on a more holistic vision of human and social development. In this regard, the declaration set the target that by 2030 all learners “acquire knowledge and skills needed to promote sustainable development” and these include what are typically mentioned in frameworks of GCED: sustainable lifestyles, human rights, gender equality, a culture of peace and non-violence, and appreciation of cultural diversity, among others. Additionally, as more educational stakeholders recognize the importance of GCED, various conceptual definitions and frameworks have been proposed for the teaching and assessment of global citizenship competencies [5,6], while different educational systems, including those in Asia, have started discussing how to best define GCED in ways that best suit their national educational aspirations [7].

### *1.2. Status of Global Citizenship Education in the Philippines*

There is currently no national GCED curriculum of global citizenship learning outcomes defined in the Philippines, but there are articulations related to the importance of human rights, global aspirations, among others, in current curriculum learning guides and materials [8]. As mentioned earlier, numerous global citizenship competencies are included in existing curriculum guides, particularly in the social studies curriculum and the values education curriculum [3]. However, there is still no official definition or framework for discussing global citizenship competencies, and discussions have noted the challenges in integrating a global citizenship component in the Philippines curriculum that associates civic consciousness with national identity [9], which in turn is fraught because of the legacies of the country's colonial history [9,10].

As part of the efforts to move forward in its aspirations to develop global citizenship in the national curriculum, the Philippines participated in the 2018 Programme for International Student Assessment (PISA) which assessed global competencies. The assessment of global competencies was based on a clear framework for defining and characterizing the multiple dimensions of global competencies [11]. However, the Philippines'

participation in this assessment cannot be interpreted as indicating that the country is adopting the PISA framework of global competencies for the country's GCED curriculum. On the other hand, the Philippines actively participated in efforts to define a framework for global citizenship competencies with other Southeast Asian countries within the SEA-PLM project. This is another multi-country large-scale assessment of educational outcomes that focused on countries in the Southeast Asian region, and the Philippines was one of the countries that contributed to the development of the conceptual framework, as well as the assessment framework for evaluating students' global citizenship competencies [12]. As such, the dimensions of global citizenship competencies defined in the SEA-PLM competencies are more likely to reflect the Philippine educational system's own discussions about GCED development in the country.

### *1.3. The SEA-PLM Framework*

The SEA-PLM global competencies framework proposed a working definition of global citizenship: "Global citizens appreciate and understand the interconnectedness of all life on the planet. They act and relate to others with this understanding to make the world a more peaceful, just, safe and sustainable place." ([12], p. 6). The working definition is a basic conceptual frame within which individual Southeast Asian countries can further develop their respective definitions. However, the focus on connectedness is intended to refer to connections among different groups of people, and between peoples and the environment. The emphasis on active global citizenship is expressed with the aim of improving the conditions of peace, equity, safety, and sustainability in the world ([12], p. 6).

As this definition was intended to provide a framework for assessing global citizenship competencies among Southeast Asian students, the framework also specified that there are three types of interrelated competencies: (a) cognitive understanding, (b) attitudes and values, and (c) behaviors and skills ([12], p. 6). More specifically, the cognitive aspects relate to understanding, analyzing, and evaluating global structures, systems, issues, and other concepts. Attitudes and values refer to having positive inclinations and beliefs related to global citizenship concepts and experiences. Finally, behaviors refer to acting, participating, and other skills that are important in creating positive social change.

These competencies are understood to be related or applied to different global citizenship content, which are organized into three clusters: (a) systems, issues, and dynamics, (b) awareness and identities, and (c) engagements [12]. The first cluster refers to a range of concepts that relate to interactions among institutions and countries in the global community, such as inequalities in the distribution of wealth and power, principles of social justice and human rights that guide civic and civil institutions that operate globally, interconnectedness of life on the planet, and the importance of environmental sustainability, among others. The second cluster involves the notion of social identities tied to particular social and cultural norms and practices, the idea of multiple social identities of individuals, the diversity of identities across communities and countries, and how different levels of identities relate to specific roles as global citizenship. The third and final cluster refers to how individuals and collective groups may actively participate to improve conditions at the global level, and the motivations and skills needed for this type of participation. While these clusters are characterized distinctly, they should be seen as overlapping and interacting components of global citizenship competencies.

The SEA-PLM global citizenship framework can be seen as defining three sets of content clusters that are the object of three types of competencies. This attempt to build a broad working framework to define the global citizenship competencies for Southeast Asian students should be seen as allowing for flexibility and specificity for each country in the region. However, for the first cycle of SEA-PLM (2018–2019) the assessment focused only on the attitudes and values measurement subdomain, and, to a very limited extent, some of the behaviors and skills measurement subdomain were also assessed. The final factors of global competencies measured in the SEA-PLM were six latent factors intended

to measure mostly attitudes and values. Henceforth, we refer to each latent factor as an index. The index that was closest to a cognitive measure was the students' report on whether they studied or were exposed to the global citizenship topic in school:

- GCEXPOS or Exposure to Global Citizenship Topics: eleven (11) items referred to specific global citizenship topics and students were asked to indicate the extent to which they learned about each topic in school (i.e., *a lot, some, a little, or nothing*).

The three main factors or indices that measured attitudes and values were the following:

- GCLEARN or Importance of Global Citizenship Topics: nine (9) items referred to specific global citizenship topics and students were asked to indicate the degree to which they believe the topic was important or not important (i.e., *very important, important, not very important, not at all important*).
- GLOBCON or Concern about Global Issues: eight (8) items referred to specific global issues and students were asked to indicate their degree of being worried or not worried about each topic (i.e., *not at all worried, not worried, quite worried, very worried*).
- ASIDENT or Asian Identity: six (6) items inquired into whether the students see themselves as being connected and having commonalities with other Asian students. Students had to indicate their degree of agreement or disagreement (i.e., *strongly agree, agree, disagree, strongly disagree*).

Two indices were related to behaviors related to global citizenship engagement, but they were more specific measures of the students' behavioral intentions to engage in such activities:

- EXPBEHA or Intention to Do Global Citizenship Behavior: six (6) items referred to a behavior associated with global citizenship engagement and students were asked to indicate the possibility that they might do each behavior (i.e., *I will do this, I might do this, I might not do this, I will not do this*).
- GCINTEN or Intention to participate in Global Citizenship School Activity: five (5) items referred to a school activity associated with global citizenship engagement and students were asked to indicate the likelihood that they might participate in each school activity (i.e., *very likely, quite likely, not very likely, not at all likely*).

#### 1.4. Current Study

The data from a nationally representative sample of Filipino students who participated in the SEA-PLM assessment can be analyzed to see patterns in the competencies. The SEA-PLM designed questions to measure students' competencies defined in the working framework. Students' responses to specific items are supposed to combine with other designated items to form specific index scores (e.g., GLOBCON and GCLEARN) that are assumed to represent particular global citizenship competencies.

First, we assert that the student data from the assessments can be used to investigate whether the items that are supposed to form a factor positively or negatively relate to the factor. While such results cannot serve as tests for the reliability of the scale indices, they can provide information on how the individual items relate to the index. Second, and more importantly, the machine learning approach can reveal whether the specific responses of the students show a pattern of relationships that suggest an integration of competencies suggested in the framework. That is, the analysis can reveal whether the students' knowledge, attitudes, beliefs, and behavioral intentions are structured in ways that are consistent with the integrated nature of the competencies in the framework. However, the data can also reveal patterns of associations in the students' responses that do not conform with the proposed structure of the items and factors, or with other data from the students' background and classroom experiences.

The machine learning data analytic techniques can reveal whether there are student responses that tend to be strongly associated with a particular factor or competency, and

such results can provide insights into how students' global citizenship competencies might be organically organized in the students' own thoughts and belief systems. These analyses, applied to the Philippine sample, can provide detailed snapshots of the patterns within the global citizenship thoughts, attitudes, beliefs, and behavioral intentions of Filipino students. We believe that such analyses can provide specific insights that can inform global citizenship curriculum development efforts in the Philippines, and efforts related to teacher development, resource materials development, and even in developing and improving pertinent instructional and assessment approaches.

To summarize, the present study aims to mine the Philippines' SEA-PLM data on global citizenship competencies to explore patterns that will indicate how the current knowledge, beliefs, attitudes, and behavioral intentions may be organized. In particular, the following questions are explored:

- Do the students' data fit the intended index (or latent factor) of each specific global citizenship competency (as defined in the SEA-PLM assessment framework)?
- What other students' data strongly predict the intended index (or latent factor) of each specific global citizenship competency?

The answers to these questions were sought using different machine learning approaches that will allow the researchers to determine the most accurate models for predicting each defined competency factor in the assessment data.

## 2. Materials and Analytic Methods

### 2.1. The Dataset

The data from the Philippine sample in the SEA-PLM 2019 database were analyzed in the study. The data are publicly accessible after registration at the following website: [https://www.seaplum.org/index.php?option=com\\_content&view=article&id=54&Itemid=438&lang=en](https://www.seaplum.org/index.php?option=com_content&view=article&id=54&Itemid=438&lang=en) (accessed on 27 January 2021). The sample was selected first by a stratified random sampling of schools from the 16 regions, considering the following additional stratification variables: urbanization, funding, management, school type, and socioeconomic background of the school community; this step selected 176 schools. From these schools, there was random sampling of at least two classes for a target cluster sample size of 60 to 70 students [12]. However, some schools only had one section and random sampling of more than two sections was also allowed when the class sizes were small. The final sample comprised 6,083 Grade 5 Filipino students with an average age of 11.24 years ( $SD = 0.79$ ); 49.5% were girls and 50.5% were boys. Based on the collected background information from the students, 44.1% of the students who responded had parents who were skilled laborers or domestic helpers, 21.1% who were small business owners or clerks, 2.6% who were soldiers or police, 10.6% who were professionals, and 21.7% who were in other occupations. Among those who provided responses, 29.5% had parents with tertiary education, 14% with some post-secondary education, 21.3% with upper secondary or vocational/technical education, 19.5% with lower secondary education, 14.0% with lower than secondary education, and 1.6% with other responses. Only 9.3% of the students were only children, 21.9% had one sibling, 39.6% had 2 or 3 siblings, and 29.2% had 4 or more.

The indices and items that were related to global citizenship were identified for analysis. The main variables were each of the indices computed to represent global learning competencies (henceforth, GLCM). The individual items used for each index and several other items related to global competences were included as predictors of the indices, and for purposes of the report they will be referred to as variables (in contrast to the index that they are predicting).

For SEA-PLM data, these main GLCM variables were 6 indices: ASIDENT (Asian Identity), GLOBCON (Concern about Global Issues), GCLEARN (Importance of Global Citizenship Topics), GCEXPOS (Exposure to Global Citizenship Topics), EXPBEHA (Intention to Do Global Citizenship Behavior), and GCINTEN (Intention to participate in

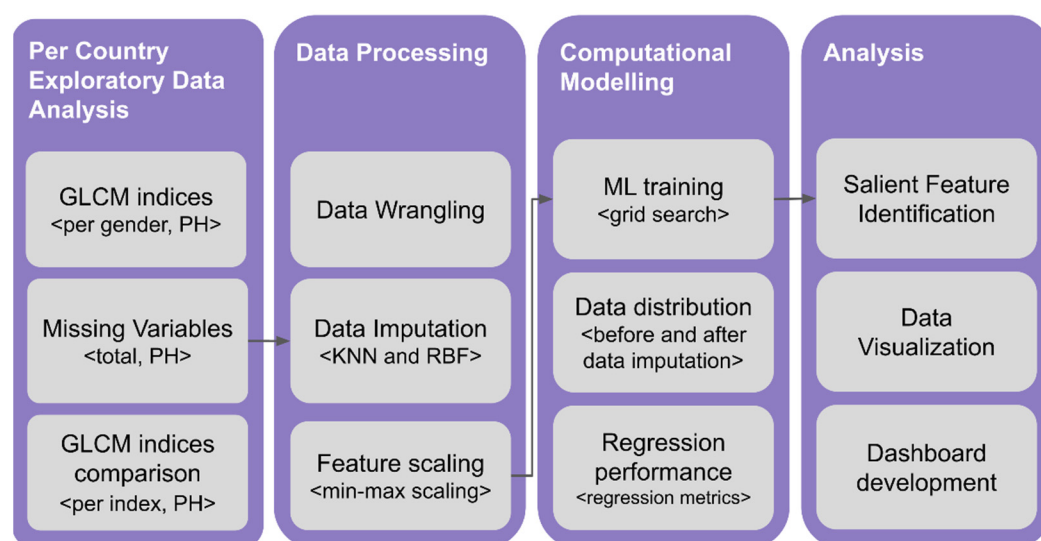
Global Citizenship School Activity). These indices were computed based on designated items; the technical documents of SEA-PLM did not specify how the index scores were combined (i.e., whether they were summed, averaged, or weighted), but the reported scores were standardized so that the mean was 50 (see Table 1 for the descriptive statistics for the 6 indices.). In addition to the 6 indices, there were another 63 variables analyzed representing the individual items in the scale and other global citizenship items (see Supplementary File for summary statistics for the 63 variables). Thus, the dataset for SEA-PLM consisted of 69 scores (indices and variables).

**Table 1.** Summary of descriptive statistics for GLCM indices.

Index	M	SD	Minimum	Maximum
GCEXPOS	51.78	11.53	1.41	99.00
GCLEARN	52.84	15.04	13.61	99.00
GLOBCON	48.93	14.30	18.19	99.00
ASIDENT	53.29	14.00	32.19	99.00
GCINTEN	54.53	14.07	21.60	99.00
EXPBEHA	50.31	13.59	21.23	99.00

## 2.2. Machine Learning Methodologies

Various data mining techniques were utilized to discover useful patterns amidst the pool of initially meaningless values. Figure 1 summarizes the components of the machine learning methodology.



**Figure 1.** Summary of the machine learning methodologies.

### 2.2.1. Data Description and Processing

The main task for the data mining study is to use regression models with target variables being the six GLCM indices. The categories of predictor variables that are relevant to global competencies are listed in Appendix A. For each of these variables, the missing values were identified and imputed using  $k$ -nearest neighbor algorithm, where  $k$  is empirically determined as being equal to 7. Finally, for data processing, normalization per variable is performed such that the variable range is from 0 to 1.

### 2.2.2. Training and Testing

For each dataset, initial grid search experiments were performed to choose the best ML model that would predict the GLCM indices. Initial ML models considered include

Support Vector Machines (SVM), Random Forests (RF), and Multilayer Perceptrons (MLPs). MLPs consistently performed comparably and often better than the others. The accuracy for the MLPs was an average  $R^2 = 0.9139$ , which was better than for RF (average  $R^2 = 0.9116$ ) and SVM (average  $R^2 = 0.8525$ ). Thus, we further finetuned MLPs throughout the study to simplify our analyses, making it easier to compare models across different datasets. (Please see Supplementary File for details of this analysis.)

Since a grid search approach was used, the hyperparameters search space for training the MLP was set (see Table 2 for summary). For each group of hyperparameters, 3-fold cross validation is used. For each fold, the dataset is split into training and test sets. The training set is used for adjusting the MLP model parameters during the backward pass guided by the prediction error quantified by the cost function and loss function. The model performance is probed using the test set data every training fold. The average performance  $R^2$  of the three folds is reported for each hyperparameter group in the grid search.

**Table 2.** Hyperparameters search field for the MLP grid search.

Hyperparameters	Range/Set of Values Considered
Hidden layer size, $N$	10, 25, 50, 75, 100
Hidden weights optimizer	SGD, Adam
$L^2$ regularization parameter	0.0001, 0.05
Learning rate schedule	constant, adaptive
Initial learning rate	0.001, 0.003, 0.01

To explain each regression model, the Shapley Additive Explanations (SHAP) approach was applied; this approach is based on cooperative games theory, to compute the contribution of each variable to the model prediction. The approach assigns Shapley values to variables determined by the average of their respective contribution to every possible variable combination.

### 3. Results

#### 3.1. Machine Learning Model Results

The important results of the machine learning methodology are the optimal models, in this case as mentioned above, the result of MLPs that consistently performed comparably and often better than the other machine learning approaches. There are several optimal MLP models to be presented in this part, as each model represents one of the six global competency indices in the SEA-PLM. As shown in Table 3, all the MLP models obtained with the training data had high accuracy rates and the accuracy rates in the test data were equally high. In the following sections, we summarize the key SHAP analysis results (for details please see Supplementary File).

#### 3.2. Most Important Predictors of GCEXPOS (Exposure to Global Citizenship Topics)

The index of Filipino students' perception of global citizenship topics learned in school was positively predicted by eight of the topics listed (e.g., current events happening in their country of origin, understanding people from a different race, and how to protect the environment), but three of the topics—current events in the world, pollution in the Philippines, and pollution in other countries had a negative impact on the index. These divergence in the data patterns indicates possible gaps in the global citizenship education curriculum in the Philippines; for example, it is possible that discussion of pollution topics are not related to the other global citizenship topics.

**Table 3.** Average  $R^2$  performance of the best MLP models for predicting the SEA-PLM global competency indices.

Index	Hyperparameters	$R^2$ (train)	$R^2$ (test)
GCEXPOS	alpha = 0.0001, hidden_layer_sizes = 75, learning_rate_init = 0.003, solver = 'sgd'	0.9035	0.9139
GCLEARN	alpha = 0.0001, hidden_layer_sizes = 100, learning_rate = 'adaptive', learning_rate_init = 0.003, solver = 'sgd'	0.9698	0.9496
GLOBCON	alpha = 0.05, hidden_layer_sizes = 25, learning_rate = 'adaptive', learning_rate_init = 0.003, solver = 'sgd'	0.9746	0.9683
ASIDENT	alpha = 0.0001, hidden_layer_sizes = 25, learning_rate = 'adaptive', learning_rate_init = 0.003, solver = 'sgd'	0.9629	0.9540
GCINTEN	alpha = 0.05, hidden_layer_sizes = 100, learning_rate = 'adaptive', learning_rate_init = 0.003, solver = 'sgd'	0.9760	0.9560
EXPBEHA	alpha = 0.05, hidden_layer_sizes = 100, learning_rate = 'adaptive', learning_rate_init = 0.01, solver = "adam"	0.9821	0.9691

However, the SHAP analysis indicates that Filipino students' perception of global citizenship topics learned in school was also positively predicted by their participation in school activities (e.g., speaking in an organized debate and in classroom discussions about problems in the world), and beliefs about societal issues (e.g., the government's role and everyone's role to protect the environment). Additionally, their awareness of important matters, worry over pollution outside the Philippines, intent to speak in an organized debate, and their feelings of connection to the world also positively predicted their perception of global citizenship topics learned in school. These positive predictors point to the emergence of some integrated global citizenship competencies related to topics and activities. There is an interesting result related to the topic of pollution. Filipino students' worry or concern about pollution in other countries is associated with other global citizenship topics, but simply covering the topic of pollution in and outside the Philippines is not. This result could be pointing to two important aspects of the global competencies: the affective concern and the global dimension. The topic of pollution become associated with global citizenship topics when students come to be worried about pollution in other countries. Finally, it was interesting to note that students' intention to vote for their class leader negatively predicted this perception of global citizenship.

### 3.3. Most Important Predictors of GCLEARN (Importance of Global Citizenship Topics)

The index for Filipino students' attitudes toward global citizenship education was positively predicted by all listed topics including current events in their country of origin and in the world, how to solve disagreements with classmates peacefully, how to protect the environment, and languages spoken in and out of the Philippines. Thus, even as the Filipino students may not have been exposed to all global citizenship topics, the Filipino students see all these topics as important for them to learn.

The index for Filipino students' attitudes toward global citizenship education was positively predicted by their concern over environmental problems (e.g., climate change and loss of natural resources) and their intent to engage in global citizenship-related activities (e.g., speaking in an organized debate and in classroom discussions about the



problems in the world). Additionally, their feelings of connection with the world, willingness to tell someone littering to stop, and their participation in voting for their class leader also positively predicted their attitudes toward global citizenship education.

### 3.4. Most Important Predictors of GLOBCON (Concern about Global Issues)

The Filipino students' concern over global issues was positively predicted by all listed environmental problems (e.g., pollution outside the Philippines, power shortages, and loss of natural resources), but pollution in the Philippines, extinction of plants, and climate change had a negative impact on the index. This result again points to possible gaps in the curricular efforts to strengthen Filipino students' concerns about global issues.

The Filipino students' concern over global issues was positively predicted by their discussions on global citizenship-related topics in school (e.g., understanding people from a different ethnicity or race, and the loss of natural resources), participation in voting for their class leader, and their intent to speak in an organized debate. On the other hand, this concern over global issues was negatively predicted by their willingness to engage in global citizenship-related activities (e.g., telling someone littering to stop, and standing up for a classmate who is being badly treated by other students), sense of belongingness to the Philippines, and their awareness that their country should help in important matters. The divergent findings point to possible discontinuities between how global citizenship topics and global citizenship actions are learned by the students, a critical issue that relates to the distinction between passive and active dimensions of global citizenship. This issue should be an important matter for discussion among curriculum developers.

### 3.5. Most Important Predictors of ASIDENT (Asian Identity)

Filipino students' attitudes about national and regional identity were positively predicted by all listed identity statements (such as feelings of belongingness to the country of origin, identifying as Asian, and sensing a connection to and commonalities with children around the world). Thus, the items in the GLCM index represented a valid indicator of Asian identity among Filipino students.

The SHAP analysis also showed that the Filipino students' attitudes about national and regional identity were positively predicted by their concern over environmental problems (e.g., pollution in and outside the Philippines and plant extinction) and beliefs about societal issues (e.g., that the world is a fair place, and that people from different ethnic/racial backgrounds should get along with each other). Additionally, their willingness to engage in global citizenship-related activities (e.g., voting for their class leader) and the importance of global citizenship-related topics (e.g., pollution in the Philippines and what is happening in nearby countries) also positively predicted Filipino students' attitudes about national and regional identity.

### 3.6. Most Important Predictors of GCINTEN (Intention to Participate in Global Citizenship School Activity)

The Filipino students' intent to take part in future activities related to global citizenship was positively predicted by all the listed activities including voting for their class leader, becoming a candidate for class leadership, joining a group of students supporting a common cause, and speaking in an organized debate and in classroom discussions about problems in the world. Thus, there seems to be a coherence in these items as they represent behavioral intentions to engage in global citizenship activities among the students.

The Filipino students' intent to engage in future global citizenship-related activities was positively predicted by their sense of belonging (e.g., feeling that they have a lot in common with children outside Asia, and feeling connected to the world), awareness of current events (e.g., that these have nothing to do with them, and that they only focus on what is important), concern over environmental problems (e.g., pollution in the Philippines and plant extinction), their participation in school activities (e.g., becoming a

candidate for class leadership and speaking in an organized debate), and the importance of learning about how things happening in other countries affect the Philippines.

### 3.7. Most Important Predictors of EXPBEHA (*Intention to Do Global Citizenship Behavior*)

Filipino students' willingness to engage in global citizenship activities was positively predicted by all the listed activities (e.g., helping someone in the community, joining a group activity to protect the environment, and telling someone who is littering to stop) except the activity involving making friends with someone from another country. This exception among the items in this index points to a possible gap in how global citizenship engagement is understood by Filipino students, which may be due simply to the lack of opportunities for most Filipino Grade 5 students to even conceive of the possibility of making friends with anyone outside their own town or city, much less another country.

The Filipino students' willingness to engage in global citizenship activities was positively predicted by their participation in school activities (e.g., participating in activities to make the school more environmentally friendly, and presenting ideas to their class), their awareness of current events (e.g., that these have nothing to do with them and that they can do something to help), and their discussions of global citizenship-related topics (e.g., other languages spoken in the Philippines and understanding people from a different ethnicity/race). Additionally, their belief that the world is fair, their intent to speak in an organized debate, and their sense of belongingness to their country also positively predicted their willingness to engage in global citizenship-related activities. On the other hand, their intent to vote for their class leader negatively predicted their willingness to take part in global citizenship-related activities; perhaps electoral behaviors are not seen as being connected with global citizenship, which might explain why it is unrelated to the students' willingness to engage global citizenship activities in the future.

## 4. Discussion

This study was conducted to explore the current knowledge, beliefs, attitudes, and behavioral intentions of Filipino Grade 5 students who participated in the SEA-PLM assessment, with the aim of characterizing the emerging global competencies of Filipino students. The exploratory study aimed to provide a snapshot, so to speak, of what Filipino students' global competencies are beyond the score means, which indicate what they know or do not know. Instead, the exploratory study used machine learning approaches to explore how different specific items of knowledge, beliefs, or intentions relate to the main competencies measured in the SEA-PLM indices.

We wish to underscore that machine learning approaches, including MLP, are mainly used for predictive modeling, and should not be viewed as testing explanatory models, and especially not causal models. The models generated in MLP and other machine learning approaches are not assumed to reflect a theoretical account of the constructs measured and their relationships. Instead, the models specify relationships among the constructs measured that allow predictions to be made about the constructs. The distinction between predictive modeling and explanatory modeling is discussed extensively by others [13] and should guide how to interpret and appreciate the results of the study. For example, the results should not be interpreted as indicating any form of causal relationship between the variables in the indices. This is also because the SEA-PLM data are cross-sectional, and do not allow for causal relationships to be tested among measured variables.

Some education scholars view predictive models that are the results of machine learning approaches as being limited as they do not point to causal relationships involving factors that can be changed or modified in the educational environment. As such, others have proposed combining machine learning approaches with statistical approaches that allow for explanatory modeling [14,15]. Indeed, using a complementary set of analytic approaches will be most useful for future studies that begin inquiring into how specific factors might be shaping students' global citizenship competencies. However, given the limited aims of the current study of identifying factors that predict the indices, the

machine learning approach of MLP reveals some insights. We note that MLP has been used in educational research to predict specific educational outcomes [16,17], and in some studies that predict outcomes in international large-scale assessment [18,19].

We highlight some of the interesting results from the predictive models found using MLP. First, the six indices constructed by the SEA-PLM were mostly internally consistent across indicated by the strong prediction of the pertinent items in the SHAP analysis. As would be expected, the items that comprise an index were the strongest predictors of most indices and all countries. However, it should be noted that in the case of GCEXPOS (students' reports on the global citizenship topics they had learned in school) and GLOBCON (students' reports on their concern about global issues) index items seem to be least internally consistent. Three items in the GCEXPOS index negatively predicted the index, which might suggest that these topics were not covered to the same degree as the other topics in the index. Three items in the GLOBCON index also negatively predicted the index, which might suggest that the students' level of concern about these topics were not in the same direction as for the other topics. These insights from the students' responses are very important guides for global citizenship curriculum developers, as they suggest either gaps, inconsistencies, or uneven coverage across the different global citizenship topics. Still related to this point, Filipino students' concern about concern or worry about pollution in the Philippines and outside the country positively predicted the GCEXPOS index even as the coverage of those topics negatively predict the same index. So, the students experience learning about pollution in their classes seems to be negatively associated with their level of concern about pollution. These results underscore the need to appreciate the multidimensionality of global citizenship competencies. Not only are these competencies limited to cognitive understanding, but they also have affective and behavioral dimensions, and curriculum developers should ensure that the students' curricular experiences allow for the development of all the dimensions of global citizenship competencies.

We also observe that items in one index also tend to be strongly predictive of other indices. These are interesting because while the indices are latent factors that represent a particular aspect of global competencies, their relationships with other variables support the idea of the multidimensionality of global citizenship competencies. For example, the belief that pollution is an important global issue and concern about pollution and other environmental issues tend to be positively predictors of the different indices. The feeling of being connected to people in other countries, the understanding of the natural disasters in other countries also affect them, the belief that it is important to learn about other countries and how different countries affect each other also tend to be positively predictive of the global competency indices. Not only do these associations suggest the beginnings of some integrated set of knowledge, beliefs, and attitudes related to global citizenship, they also point to possible scaffolds for building other global competencies. For example, concern topics on climate change and environmental sustainability seems to be a good anchor for relating other knowledge and attitudes. A global citizenship learning module or teacher can use the idea that natural disasters in other countries also affect us and nurturing the sense of being connected to people from other countries, while encouraging learning more about other countries and how they all relate to each other. These specific concepts and values can be the scaffold for other global citizenship topics, given how they tend to be positively associated with a number of the global competency indices.

Aside from specific topics, students' willingness to participate in future school activities were positively associated with global competency indices. Willingness to participate in debates in their school consistently positively predicted global competency indices. As such, debates and class elections can be potentially powerful classroom activities to try to nurture different global competencies. This result is consistent with previous studies showing that class debates is not just a good tool for developing language skills, but also for developing critical thinking across different subjects in the curriculum [20,21]. Interestingly, willingness to participate and vote in classroom elections had mixed associations with the indices. Willingness to vote had a positive impact on the three attitude indices

(i.e., GCLEARN, GLOBCON, ASIDENT), but had a negative impact on the index on topics covered in class (GCEXPO) and behavioral intentions to participate in future global citizenship activities outside class. Previous studies in other democratic countries find that classroom elections, including mock elections, can be useful pedagogical tools in citizenship education [22,23], but its usefulness in the Philippine primary school context might need to be more carefully studied as to how students might perceive such an activity.

We should note that all the data analyzed were gathered from students in 2019, before the COVID-19 pandemic. The SEA-PLM data and results were released late in 2020, and the analysis for the current study were undertaken in 2021 to 2022. Thus, the snapshot of Filipino students' global citizenship knowledge, attitudes, beliefs, and behavioral intentions do not reflect how the pandemic may have changed how young Filipinos understand the interconnectedness of countries and peoples. It is possible that understanding the global scale of the impact of COVID-19 might make some global citizenship competencies more salient. However, as Filipino schools have been closed from March 2020 and will remain closed until August 2022, we are not sure how Filipino students were able to process the global experiences during the pandemic. Future research using the SEA-PLM assessment in 2024 might provide interesting insights on how the pandemic may have shaped Filipino students' global competencies.

However, we believe that the findings should be appreciated within the context of Southeast Asian empirical research on GCED, which is presently focused on curriculum development plans [24,25] and on perceptions and practices of teachers [26,27], which are also two of the focal areas of empirical work on GCED according to reviews [28]. Our results contribute to a different area of focus—the students. A systematic review [28] found that most studies on students examine the effects of global citizenship curriculum or activities on students and inquire into students' perceptions and understandings of global citizenship as a concept and of GCED. Our study is not focused on student outcomes, and how these elements might be integrated or not integrated. The interrelatedness of the elements of global competencies was revealed using machine learning approaches, which allows us to have a sense of the emerging structure of Filipino student global citizenship competencies in ways that simple descriptive statistics would not allow. The machine learning approach was applied to a large dataset of a nationally representative sample of Filipino primary school students who participated in a regional large-scale educational assessment (SEA-PLM), and this is the first study that mines the rich data from that survey for the purpose of inquiring into global citizenship competencies.

## 5. Conclusions

Beyond the descriptive statistics (frequencies and averages), the SEA-PLM provides curriculum developers with rich detailed information about how different global citizenship competencies are presently configured among Filipino Grade 5 students. Even as the Philippines has not yet developed or implemented a formal global citizenship education curriculum, applying powerful data analytic tools on the raw data shows how the young students' global citizenship competencies are gradually developing in their primary years of schooling. There are kernels of knowledge, beliefs, attitudes, and behavioral intentions that seem to converge in positively predicting the defined global competency indices. These emerging global citizenship competencies can be the scaffolds for shaping the global competencies further.

We note that machine learning approaches have been used in education to study predictors of achievement [29–31]. MLP, in particular, has been used to generate models for predicting specific student learning factors [16,17], even applied to data from international large-scale assessment [18,19] similar to the current study. However, our study applies machine learning approaches to try to explore the structure of students' emerging competencies in an important domain of learning. Describing students' prior knowledge has long been a foundational principle in constructivist approaches to curriculum development [32,33]. By using machine learning approaches, we hope to contribute toward global

citizenship education curriculum development efforts in the Philippines by providing some insights about Filipino students' current competencies in the domain.

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**Data Availability Statement:** The data analyzed in this study are publicly available in the SEA-PLM Datasets and Questionnaire page and can be accessed after registration on the website: [https://www.seaplm.org/index.php?option=com\\_content&view=article&id=54&Itemid=438&lang=en](https://www.seaplm.org/index.php?option=com_content&view=article&id=54&Itemid=438&lang=en) (accessed on 27 January 2021).

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## Appendix A

Summary of categories of predictor variables relevant to global competencies

Variable Category	Description
GC01	Learn—Awareness of global cultures and issues
GC02	School—Student participation history in discussions and debates
GC03	Identity—Student perception of own Asian identity relative to other Asian countries
GC04	Global—Feeling towards global issues
GC05	Community—Feeling towards community issues
GC06	Issue—Attitude towards global issues
GC07	Activity—Willingness to participate or help others
GC08	Awareness—Feeling towards engaging global issues
GC09	Engage—Willingness to engage global issues
GC10	Belief—Student perception of importance of global issues

## References

1. United Nations. *Global Education First Initiative*; United Nations: New York, USA, 2012. Available online: [https://www.gcedclearinghouse.org/sites/default/files/resources/%5BENG%5D%20Global%20Education%20First%20Initiative\\_0.pdf](https://www.gcedclearinghouse.org/sites/default/files/resources/%5BENG%5D%20Global%20Education%20First%20Initiative_0.pdf) (accessed on 19 June 2022).
2. United Nations Educational, Scientific, and Cultural Organization. *Global Citizenship Education: Preparing Learners for the Challenges of the 21st Century*; UNESCO: Paris, France, 2013. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000227729> (accessed on 25 July 2022).
3. Hibanada, R.R.; Dellomos, C.O.; Romero, R.C. PISA global competence framework vis-a-vis Philippine 2016 K to 12 curriculum in social studies and values education. In *Challenges of PISA: The PNU Report*; Balagtas, M.U., Montealegre, M.C., Eds.; Philippine Normal University and Rex Institute for Student Excellence, Inc.: Manila, Philippines, 2020; pp. 142–193.
4. United Nations Educational, Scientific, and Cultural Organization. *Education 2030: Incheon Declaration and Framework for Action*; UNESCO: Paris, France, 2016. Available online: [http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en\\_2.pdf](http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf) (accessed on 31 March 2022).
5. Pashby, K.; da Costa, M.; Stein, S.; Andreotti, V. A meta-review of typologies of global citizenship education. *Comp. Educ.* **2020**, *56*, 144–164. <https://doi.org/10.1080/03050068.2020.1723352>.
6. Schulz, W.; Ainley, J.; Fraillon, J.; Kerr, D.; Losito, B. *ICCS 2009 International Report: Civic Knowledge, Attitudes and Engagement among Lower Secondary School Students in Thirty-Eight Countries*; International Association for the Evaluation of Educational Achievement (IEA): Amsterdam, The Netherlands, 2010. Available online: [https://www.iea.nl/sites/default/files/2019-04/ICCS\\_2009\\_International\\_Report.pdf](https://www.iea.nl/sites/default/files/2019-04/ICCS_2009_International_Report.pdf) (accessed on 6 May 2022).
7. United Nations Educational, Scientific, and Cultural Organization. *2018 Asia Pacific Regional Global Citizenship Education Network Meeting*; UNESCO: Jakarta, Indonesia, 2018.
8. Maribojoc, J.G. The Philippines: Global citizenship education (GCED) and education for sustainable development (ESD) in basic education. In *2018 Asia Pacific Regional Global Citizenship Education Network Meeting*; UNESCO: Jakarta, Indonesia, 2018.
9. Maca, M.; Morris, P. Education, national identity and state formation in the modern Philippines. In *Constructing Modern Asian citizenship*; Vickers, E., Kumar, K., Eds.; Routledge: London, UK, 2014; pp. 139–162.
10. Adarlo, G.M. (Re)framing citizenship education in the Philippines: A twenty-first century imperative. *Good Soc.* **2017**, *25*, 256–288. <https://doi.org/10.5325/goodsociety.25.2-3.0256>.
11. Organization for Economic Co-Operation and Development. *PISA 2018 Global Competence Framework*; OECD Publishing: Paris, France, 2019. Available online: [https://www.oecd-ilibrary.org/education/pisa-2018-assessment-and-analytical-framework\\_043fc3b0-en](https://www.oecd-ilibrary.org/education/pisa-2018-assessment-and-analytical-framework_043fc3b0-en) (accessed on 3 March 2020).
12. United Nations Children’s Fund; Southeast Asian Ministers of Education Organization. *SEA-PLM 2019 Global Citizenship Assessment Framework*, 1st ed.; UNICEF & SEAMEO—SEA-PLM Secretariat: Bangkok, Thailand, 2017. Available online: <https://www.seaplm.org/PUBLICATIONS/frameworks/sea-plm%202019%20global%20citizenship%20assessment%20framework.pdf> (accessed on 27 January 2021).
13. Shmueli, G. To explain or to predict?. *Stat. Sci.* **2010**, *25*, 289–310.
14. Hastie, T.; Tibshirani, R.; Friedman, J. *The Elements of Statistical Learning*; Springer: New York, NY, USA, 2009; <https://doi.org/10.1007/978-0-387-84858-7>.
15. Lezhnina, O.; Kismihók, G. Combining statistical and machine learning methods to explore German students’ attitudes towards ICT in PISA. *Int. J. Res. Method Educ.* **2022**, *45*, 180–199. <https://doi.org/10.1080/1743727X.2021.1963226>.
16. Kayri, M. An intelligent approach to educational data: Performance comparison of the multilayer perceptron and the radial basis function artificial neural networks. *Educ. Sci. Theory Pract.* **2015**, *15*, 1247–1255. <https://doi.org/10.12738/estp.2015.5.0238>.
17. Qu, S.; Li, K.; Zhang, S.; Wang, Y. Predicting achievement of students in smart campus. *IEEE Access* **2018**, *6*, 60264–60273. <https://doi.org/10.1100/ACCESS.2018.2875742>.
18. Güre, Ö.B.; Kayri, M.; Erdoğan, F. Analysis of factors effecting PISA 2015 mathematics literacy via educational data mining. *Educ. Sci.* **2020**, *45*, 393–415. <https://doi.org/10.15390/EB.2020.8477>.
19. Koyuncu, İ. Investigation of mathematics-specific trend variables in PISA studies with neural networks and linear regression. *J. Curr. Teaching* **2020**, *9*, 40–54. <https://doi.org/10.5430/jct.v9n4p40>.
20. Kennedy, R.R. The power of in-class debates. *Act. Learn. High. Educ.* **2009**, *10*, 225–236. <https://doi.org/10.1177/146978709343186>.
21. Merrell, B.; Calderwood, K.J.; Graham, T. Debate across the disciplines: Structured classroom debates in interdisciplinary curricula. *Contemp. Argument. Deb.* **2017**, *37*, 57–74.
22. Haas, M.E. The presidency and presidential elections in the elementary classroom. *Soc. Educ.* **2004**, *68*, 340–347.
23. Pasek, J.; Feldman, L.; Romer, D.; Jamieson, K.H. Schools as incubators of democratic participation: Building long-term political efficacy with civic education. *Appl. Dev. Sci.* **2008**, *12*, 26–37. <https://doi.org/10.1080/10888690801910526>.
24. Alviar-Martin, T.; Baidon, M.C. Issues-centred global citizenship education in Asia: Curricular challenges and possibilities in nation-centric and neoliberal times. *Curric. Perspect.* **2016**, *36*, 65–75.
25. Ho, L.C. Conceptions of global citizenship education in East and Southeast Asia. In *The Palgrave Handbook of Global Citizenship and Education*; Palgrave Macmillan: London, UK, 2018; pp. 83–95. [https://doi.org/10.1057/978-1-137-59733-5\\_6](https://doi.org/10.1057/978-1-137-59733-5_6) (accessed on 15 June 2022).
26. Jung, B.; Bang, Y. Study of teachers’ perceptions on global citizenship education ASEAN region. *Int. Underst. Ed. Res.* **2020**, *15*, 141–203.

27. Yeoh, M.P. Global citizenship education in secondary science: A survey on ASEAN educators. *J. Sci. Math. Educ. Southeast Asia* **2017**, *40*, 63–82.
28. Goren, H.; Yemini, M. Global citizenship education redefined—A systematic review of empirical studies on global citizenship education. *Int. J. Educ. Res.* **2017**, *82*, 170–183. <https://doi.org/10.1016/j.ijer.2017.02.004>.
29. Bernardo, A.B.I.; Cordel, M.O., II; Lucas, R.I.G.; Teves, J.M.M.; Yap, S.A.; Chua, U.C. Using machine learning approaches to explore non-cognitive variables influencing reading proficiency in English among Filipino learners. *Educ. Sci.* **2021**, *11*, 628. <https://doi.org/10.3390/educsci111100628>.
30. Chen, J.; Zhang, Y.; Wei, Y.; Hu, J. Discrimination of the contextual features of top performers in scientific literacy using a machine learning approach. *Res. Sci. Educ.* **2019**, *47*, 27–33. <https://doi.org/10.1007/s11165-019-9835-y>.
31. Dong, X.; Hu, J. An exploration of impact factors influencing students' reading literacy in Singapore with machine learning approaches. *Int. J. Engl. Linguist.* **2019**, *9*, 52–65. <https://doi.org/10.5539/ijel.v9n5p52>.
32. Hand, B.; Treagust, D.F. Student achievement and science curriculum development using a constructive framework. *School Sci. Math.* **1991**, *91*, 172–176.
33. Roschelle, J. Learning in interactive environments: Prior knowledge and new experience. In *Public Institutions for Personal Learning*; Falk, J., Dierking, L., Eds.; American Association of Museums: Washington, DC, USA, 1997; pp. 37–54.