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Science literacy promotes energy conservation behaviors in Filipino youth via climate change knowledge efficacy: Evidence from PISA 2018

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Abstract

Today's youth will inherit the brunt of climate change. Science literacy plays a critical role in raising future adults who commit to climate change mitigation by reducing daily household energy use. The objective of this study was to examine the mediating role of climate change knowledge efficacy on the positive influence of science literacy on engagement in energy conservation at home among Filipino adolescents. Data from the Program for International Student Assessment 2018 which included 7233 15-year-old high school students from 187 schools across 17 regions in the Philippines was used to address the study's objective. Results showed that climate change knowledge efficacy fully mediated the positive association between science literacy and household energy conservation among Filipino adolescents. The study discussed the importance of emphasizing environmentalism in science education, parenting, and community programs as a viable and long-term climate change mitigation response.

Keywords: climate change; science literacy; energy conservation; PISA; Philippines

Introduction

Today's youth will face the future consequences of climate change, and they will play a crucial role in solving the challenges brought about by environmental issues. Environmental science recognizes that science literacy plays an important role in addressing the present and future environmental problems including climate change (Johnson et al., 2014; Mueller & Tippins, 2012). Despite this, little research is known about the role of science literacy in improving mitigation behaviors especially in countries that are highly vulnerable to the consequences of climate change. In the Philippines, adults' public perception of climate change was relatively low (Bollettino et al., 2020) despite being one of the countries most affected by climate change consequences (e.g., droughts and extreme cyclones), which have been taking thousands of Filipino lives, destroying households, and ruining livelihoods (Acosta et al., 2016; Blanc & Strobl, 2016). To date, no research has examined the influence of science literacy on climate mitigation behaviors among the young generations of Filipinos. Moreover, little is known about the processes and underlying psychological mechanisms that facilitate the influence of science literacy on climate mitigation behaviors in the young generation. To address these important gaps, the present study investigates the impact of science literacy on reducing energy use at home using a nationally representative sample of 15-year-old high school students across all the regions in the Philippines. Moreover, the study examines the mediating role of climate change knowledge efficacy on the influence of science literacy on

energy conservation. This study utilized the Philippine data in the Program for International Student Assessment (PISA) 2018 conducted by the Organisation for Economic Co-operation and Development (OECD).

Predictors of climate mitigation behaviors

Climate change mitigation behaviors are defined as actions that reduce greenhouse gas emissions including minimizing engagement in specific activities such as car use, meat consumption, and unnecessary use of home appliances, among others (Bofferding & Kloser, 2015; Lawson et al., 2019). In this study, engagement in household energy conservation (e.g., turning the air conditioning up or down or by turning off the lights when leaving a room) was the main interest. Previous studies showed that several factors may be categorized as sociodemographic (e.g., age, gender, education, income, household size, house ownership, and geographical locations, among others) and psychological domains (e.g., knowledge and environmental awareness, values, attitudes and beliefs, motivations and goals, personal and social norms, perceived responsibility, self-efficacy, perceived behavioral control, among others) that predict people's engagement in household energy conservation (Frederiks, Stenner & Hobman, 2015). For example, past findings that examined the influence of sociodemographic factors on household energy consumption showed that more educated people tend to engage more in energy conservation behaviors (Nair, Gustavsson & Mahapatra, 2010) (although findings in the literature tend to be mixed). In addition, individuals with full-time jobs tend to engage in reduced energy use due to their capacity to afford energy-efficient household equipment and less time spent at home (Frederiks et al., 2015). On the other hand, a substantial number of studies showed that higher income households tend to consume more energy than lower-income households (Abrahamse & Steg, 2009, 2011; Never & Albert, 2021). However, findings on age and gender differences in energy conservation were rather mixed (Abrahamse & Steg, 2009; Frederiks et al., 2015).

In terms of psychological predictors of energy conservation, past studies demonstrated that people who have greater knowledge about environmental issues and their consequences, and those who endorse pro-environmental attitudes, beliefs, values, and self-transcendent goals and motives tend to engage more in household energy conservation (Abrahamse & Steg, 2011; Andor, Gerster, Peters & Schmidt, 2020; Aruta, 2021a; Carmi, Arnon & Orion, 2015; Dunlap, Grieneeks & Rokeach, 1983; Frederiks et al., 2015).

For instance, a study among elementary education students in Turkey showed that personal norms and biospheric values increase, whereas egoistic values reduce engagement in energy conservation behaviors (Sahin, 2013). In line with the focus of the present research, there are a few studies that looked into the role of science literacy on household energy conservation (DiMatteo et al., 2014; Johnson et al., 2014; Mueller & Tippins, 2012; van den Broek, 2019). However, one critical gap in the literature is the little scientific attention given to the psychological mechanisms that facilitate the distant relationship between science literacy and household energy conservation. The current study addresses this gap by examining the mediating role of climate change knowledge efficacy on the positive (but distant) influence of science literacy on home energy conservation behaviors among the youth in the Philippines.

The role of efficacy

Research on environmental education and environmental psychology emphasized that there was a knowledge-action gap in the environmental domain (Knutti, 2019). That is, acquiring knowledge about environmental problems and their scientific bases does not always lead to pro-environmental behaviors. Predictors of pro-environmental behaviors are complex and nuanced (Bissing-Olson, Fielding, & Iyer, 2016). Additionally, the distal nature of the knowledge and behavior relationship requires an examination of potential intervening factors that could explain this association. This study argues that climate change knowledge efficacy is an important

mediating mechanism that links the positive relationship between science literacy and household energy conservation behaviors among the youth. Guided by the PISA OECD 2018, this study defined climate change knowledge efficacy as a student's belief about one's knowledge and capability to discuss issues relating to climate change.

The current study is anchored on the Social Cognitive Theory (Bandura, 1977, 1986) which proposed that knowledge is not enough to motivate people, especially children, to engage in actual behaviors. The theory explained that self-efficacy, or a person's belief about his or her capacity to successfully carry out a task, plays an important role in motivating them to act. That is, people who believe in their capability to perform a task and successfully reap its positive consequences are more likely to engage in such tasks or behaviors. A few studies outside the environmental domain had demonstrated the facilitating role of self-efficacy on the literacy and behavior association. For instance, digital literacy was found to increase engagement in online learning activities *via an* increase in self-efficacy among online postgraduate students in Australia (Prior, Mazanov, Meacheam, Heaslip & Hanson, 2016). Following this line of thinking, the current study aims to examine the mediating role of climate change knowledge efficacy on the positive association between science literacy and household energy conservation. Although there exists evidence on the importance of science literacy on household energy conservation behaviors (Johnson et al., 2014; Mueller & Tippins, 2012; van den Broek, 2019), no research has been done on the mediating role of climate change knowledge efficacy on the science literacy and household energy conservation link especially among the youth in a climate-vulnerable and non-Western country like the Philippines.

Climate change education in the Philippines

Climate change education is relatively new in Philippine education. The integration of climate change education in the school curricula covers knowledge- and capacity-building towards climate mitigation. For example, students are educated about household energy conservation, tree planting, reducing, reusing, and recycling materials, among others in science classes. The social, environmental, and moral importance of these mitigation actions is emphasized in social science and values subjects (Department of Education, n.d.). More emphasis is given to climate adaptation and disaster risk reduction due to the country's vulnerability to climate consequences (i.e., extreme weather events such as supertyphoons and droughts). Recognizing the need to raise awareness and to equip Filipinos to respond to climate change consequences such as extreme weather events constantly faced by the country, the first National Conference on Climate Change Adaptation in 2007 (Peralta, 2008) called for the need to integrate climate change education in the Philippine school curricula. Additionally, the passing of the Climate Change Act of 2009 or the Republic Act 9729 paved the way for the inclusion of climate change education across several subjects in the primary and secondary school curricula. Consequently, the Department of Education (DepEd) issued an order (i.e., DepEd order 82 series of 2010) providing the implementing guidelines in climate education (Reyes et al., 2011). The Enhanced Basic Education Act of 2013 or the K-12 Act further boosted the integration of climate change education across grade levels, with climate change adaptation and disaster response being introduced in Science, Health, Social Studies, and Values subjects in preschool to junior high school. In senior high school, climate change education is integrated into Earth Science and Earth and Life Science courses in the STEM program. These steps in the education sector are consistent with one of the United Nations Sustainable Development Goals to address and mitigate the impact of climate change. Despite these efforts, there is still an urgent need for more active implementation of educational and national policies to increase climate literacy and awareness among the Filipino youth and the general adult population (Bollettino et al., 2020; Lucagbo, Cobrador, de Mesa, Ferrera & Marasigan, 2013).

The present study

Using a nationally representative sample of 15-year old Filipino high school students from 187 schools across 17 Philippine regions based on the PISA OECD 2018 data, the current research investigated whether science literacy would positively predict the participants' engagement in energy conservation at home. Moreover, the main interest of the present study was to examine whether climate change knowledge efficacy would serve as a significant mechanism that bridges the positive impact of science literacy on household energy conservation behaviors. This will be indicated by a significant indirect effect of science literacy scores on participants' self-reported household energy conservation behaviors *via an* increase in their climate change knowledge efficacy scores.

Simply put, I proposed the following hypotheses:

H1: High school students with higher levels of science literacy will report greater engagement in household energy conservation behaviors among the Filipino youth.

H2: Climate change knowledge efficacy will mediate the positive association between science literacy and household energy conservation behaviors.

Method

Data and procedures

The study involved a representative sample ($N = 7233$) of 15-year-old high school students from the Philippines based on the OECD PISA 2018. There were 53.48% females and 46.52% males. Using stratified sampling, the participants were recruited from 187 schools across 17 regions (see Table 1).

Measures

Science literacy

The science literacy index was derived from students' responses to several science questions which were then mathematically calculated to arrive at plausible values (OECD, 2019). Plausible values are random values from the posterior distributions based on students' science literacy scores. Following PISA Data Analysis Manual 2009 (OECD, 2009), 1 out of 10 plausible values (i.e, PV3) was randomly selected to represent the students' science literacy scores. Selecting only one plausible value is recommended as calculating the composite score of the 10 plausible values would underestimate the science literacy scores.

Climate change knowledge efficacy

The PISA dataset has two items to measure the climate change knowledge efficacy: "Explain how carbon-dioxide emissions affect global climate change." and "Explain why some countries suffer more from global climate change than others." Students were asked how easy it is for them to perform the two above-mentioned tasks through a 4-point scale ranging from 1 = *I couldn't do this* to 4 = *I could do this easily*. The combined scores of the participants in the two items were calculated to arrive at the climate change knowledge efficacy composite.

Energy conservation

There was one item in the PISA 2018 that assesses the participants' engagement in energy conservation behaviors at home: "I reduce the energy I use at home (e.g. by turning the heating down or turning the air conditioning up or down or by turning off the lights when leaving a room) to protect the environment." Using dichotomous choices (1 = *Yes*, 2 = *No*), participants indicated their engagement in home energy conservation. Responses were reverse-coded prior to analysis.

Table 1. Distribution of the participants across the Philippine regions

Regions	<i>f</i>	%
Region 1	406	5.61
Region 2	253	3.50
Region 3	878	12.14
Region 4A	1163	16.08
Region 4B	242	3.35
Region 5	485	6.71
Region 6	411	5.68
Region 7	463	6.40
Region 8	354	4.89
Region 9	238	3.29
Region 10	201	2.78
Region 11	344	4.76
Region 12	282	3.90
NCR	879	12.15
CAR	121	1.67
Caraga Region	191	2.64
NIR	322	4.45
Total	N = 7233	100%

CAR = Cordillera Administrative Region; NCR = National Capital Region; NIR = Negros Island Region.

Controlled variables

Gender and environmental values were set as covariates as suggested by the literature (Sakellari & Skanavis, 2013; Vicente-Molina, Fernández-Sainz & Izagirre-Olaizola, 2018). For example, a study among university students in Spain showed that females engage more in pro-environmental behaviors than their male counterparts (Vicente-Molina et al., 2018). Environmental values were measured using the PISA item: “Looking after the global environment is important to me.” which was rated on a 4-point scale (1 = *strongly disagree* to 4 = *strongly agree*). Substantial research demonstrated that greater environmental values lead to pro-environmental behaviors (Dunlap et al., 1983; Van der Werff, Steg & Keizer, 2014).

Results

Preliminary analysis

Descriptive statistics, estimates of normality, and correlations among the variables are shown in Table 2. Skewness and kurtosis values < |2| suggested an approximately normal distribution for science literacy, climate change knowledge efficacy, and energy conservation. Bivariate correlations showed that science literacy was positively and significantly associated with climate change knowledge efficacy (*r* = 0.39) with energy conservation behaviors (*r* = 0.44). Additionally, climate change knowledge efficacy was positively and significantly correlated with energy conservation (*r* = 0.10).

Table 2. Descriptive statistics and bivariate correlations among the variables

Variables	Mean	SD	Skewness	Kurtosis	1	2
1. Science literacy	357.44	74.61	0.54	0.26		
2. Climate change knowledge efficacy	5.38	1.54	-0.35	-0.28	0.39***	
3. Household energy conservation	1.83	0.38	-1.72	0.97	0.44***	0.10***

*** $p < 0.001$.

Mediation analysis

To assure whether there is a significant prediction of science literacy on household energy conservation behaviors before the inclusion of the mediator climate change knowledge efficacy into the model, a linear regression was employed which showed a significant result ($\beta = 0.04$, $SE = 0.006$, $p < 0.001$). A significant total effect of science literacy on energy conservation behaviors was found ($\beta = 0.026$, $SE = 0.01$, $p < 0.05$, 95% CI [0.001, 0.05]). As shown in Figure 1, the inclusion of the climate change knowledge efficacy showed a significant indirect effect of science literacy on energy conservation behaviors (indirect effect = 0.029, $SE = 0.005$, $z = 5.99$, $p < 0.001$, 95% CI [0.02, 0.04]). No significant direct effect of science literacy on home energy conservation behaviors was found ($\beta = -0.003$, $SE = 0.01$, $p = 0.80$, 95% CI [-0.03, 0.02]) suggesting that climate change knowledge efficacy fully mediated the positive influence of science literacy on home energy conservation behaviors. Gender and environmental values were set as covariates to control for their effects.

Discussion

Today's youth will inherit the brunt of climate change. Science education plays a critical role in raising future adults who commit to climate change mitigation behaviors including reducing daily energy use. This study aimed to examine the positive influence of science literacy on home energy conservation behaviors among 15-year-old high school students in the Philippines. Moreover, this study investigated the mediating role of climate change knowledge efficacy on the positive association between science literacy and adolescents' engagement in household energy conservation. Overall, the findings revealed that climate change knowledge efficacy operates as a significant mediating mechanism in promoting the positive impact of science literacy on energy conservation behaviors at home among adolescents in the Philippines.

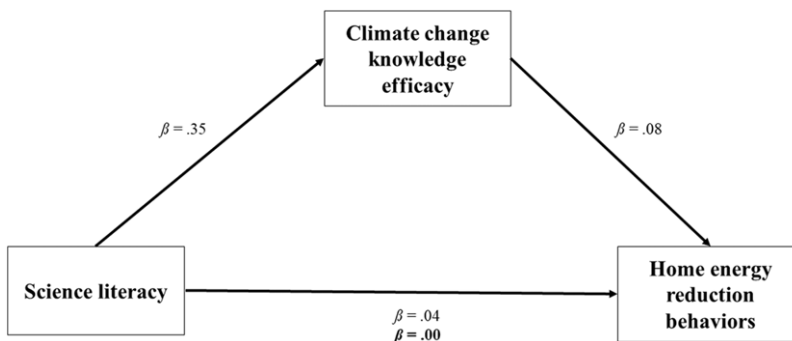


Figure 1. Final path model illustrating the mediating effect of climate change knowledge efficacy on the impact of science literacy on home energy reduction behaviors among Filipino youth. Note: Bolded coefficient indicates indirect effect.

Key findings

The first main finding of this study was that science literacy positively predicted household energy conservation behaviors, confirming H1. This suggests that students who have higher levels of science knowledge are more likely to engage in household behaviors that aim to mitigate climate change. Viewed differently, students with lower scientific knowledge are less likely to engage in household behaviors that reduce energy consumption. This finding was consistent with previous studies (Johnson et al., 2014; Mueller & Tippins, 2012; van den Broek, 2019) which showed that individuals who have higher literacy in science engage more in household actions that preserve energy resources. The current study extended this line of research by demonstrating that a similar pattern was observed among the younger generations of people in a climate-vulnerable and non-Western nation like the Philippines which has been neglected in the literature.

The most important finding of the present study was that climate change knowledge efficacy fully mediated the positive influence of science literacy on household energy conservation behaviors among Filipino youth. This suggests that students who have higher levels of scientific literacy develop a greater belief about their ability to discuss climate change issues, which in turn motivates them to reduce their household energy consumption. Viewed differently, students who have lower levels of science literacy are less likely to believe in their capacity to understand and resolve climate change-related issues, which in turn could reduce their motivation to engage in household energy conservation. This finding was consistent with previous studies showing that science literacy promotes climate change knowledge (Jordan et al., 2019) and that the role of sense of efficacy increases people's conservation behaviors (Martinez Gonzalez & Reynolds-Tylus, 2021; Muroi & Bertone, 2019). Furthermore, the present study provided support for the proposition of Social Cognitive Theory (Bandura, 1977, 1986) which emphasized that knowledge alone cannot sufficiently activate behavior and that tapping on the learners' sense of efficacy is critical. This study extended the literature by applying such a proposition in the environmental domain which was noticeably lacking in the literature.

Moreover, this finding contributed to the literature by elucidating that climate change knowledge efficacy is a significant mechanism that links the distal association between science literacy and household energy conservation behaviors. The recent educational efforts to integrate climate change education, into the Philippine school curricula (Reyes et al., 2011), which includes a science-based approach to climate mitigation (Department of Education, n.d.) can explain why science literacy appeared as a significant precursor in increasing Filipino youth's climate change knowledge efficacy, leading them to engage more in mitigation actions. It appears that teaching students the scientific aspect of climate change allows them to appreciate the extent of their capacity to understand the (often complicated) issue of climate change, leading them to identify and engage in daily actions that can help reduce their carbon footprint.

Further, the findings of this study filled the gap in the dearth of literature on the predictors of climate change mitigation in a nation that has been neglected in the environmental education literature despite being one of the countries that often faces the brunt of climate change consequences. The Philippines has been ranked third by the United Nations University Institute for Environment and Human Security (UNU-EHS) in terms of high disaster risk in its World Risk Report 2011 (UNU-EHS, 2011) and has also been constantly included in Germanwatch's Global Climate Risk Index as one of the countries that suffer the most from extreme consequences of global climate change (Kreft & Epstein, 2014). More recently, the country has been ranked by Global Peace Index (2019) as the country that is most susceptible to climate hazards. For example, Typhoon Haiyan, the most powerful super typhoon ever recorded to make landfall, hit the Philippines in 2013. It caused at least 6300 casualties, relocated at least four million people, and destroyed at least a million houses (Acosta et al., 2016; Mori et al., 2014; Tajima et al., 2014). Indeed, science education plays an important role in ensuring that the future generations of Filipinos are competent in climate change mitigation, making them less vulnerable to climate consequences.

Another important contribution of the present study is its focus on the younger generation of Filipinos using a nationally representative sample of high school students across all Philippine regions. The current study believes that attention to environmentalism among the youth is a crucial research pursuit given that they are the future adults who will inherit the future consequences of environmental decisions and actions of the past and current generations. Moreover, today's youth will continue the legacy of environmental protection (or exploitation) which will determine the future of the earth (Collado, Staats & Sancho, 2019; Katz-Gerro, Greenspan, Handy & Vered, 2020).

Additionally, this study contributed to the scarce literature on environmentalism in a non-WEIRD (Western, Educated, Industrialized, Rich, and Democratic) country like the Philippines (Aruta, 2016, 2021b, 2021c, 2021d; Aruta & Paceaño, 2021). Recent literature reviews (see Tam & Milfont, 2020; Tam, Leung & Clayton, 2021) pointed out the lack of studies that represent findings from non-WEIRD countries. It is important to note that environmental problems are not only a WEIRD problem but rather a global concern. Hence, studies from non-WEIRD nations are needed to provide a more nuanced and holistic perspective on what predicts pro-environmental behaviors. In summary, the findings of this research provided several important contributions to environmental education literature which can be used in promoting sustainability through its integration into educational programs and policies.

Limitations

The limitations of this study provide opportunities for future research. Firstly, this study only focused on science literacy and climate change knowledge efficacy as predictors of household energy conservation. Given that the participants were adolescents, other factors that could promote their engagement in energy preservation should be examined. For instance, previous research pointed out the roles of peers and parents in adolescents' pro-environmental behaviors (e.g., Collado, Evans & Sorrel, 2017). Secondly, the study focused only on 15-year-old students who participated in the OECD PISA 2018, future studies may consider examining the hypothesis among younger children and older adolescents and adults. This is important given the age-related motivations in engaging in environmentalism (Collado et al., 2017). Thirdly, the study has relied on limited items as indicators of household energy consumption (one item) and climate change knowledge efficacy (two items). Hence, studies in the future may consider utilizing tools with more indicators to assure the reliability of participants' responses. Lastly, the current research focused only on Philippine data. Future researchers may consider examining the hypotheses across countries that are vulnerable to climate change consequences. Nonetheless, the findings of the present study offered relevant insights on the important role of science education in promoting climate change mitigation behaviors among the young generation of Filipinos.

Educational implications

The findings of the present study offer several important implications for environmental education and sustainability. First, the findings elucidated that science literacy promotes engagement in household energy conservation behaviors among high school students across the regions in the Philippines. This may indicate that the integration of climate change education in the science education curriculum is effective in encouraging the students to participate in the fight against climate change. Providing a scientific perspective into the nature of climate change appears to help students in understanding the effective ways in reducing their carbon footprints. Science education programs in the country should continue emphasizing the scientific aspect of climate change and environmental-related topics as a strategy to motivate the Filipino youth to mitigate climate change. I note that given the recent findings on the significant contribution of middle-class Filipino families in energy consumption (Never & Albert, 2021), private schools in the Philippines,

where middle to upper-class Filipino students usually enroll, may play a role by integrating climate change education into their curriculum. It is important to clarify, however, it should not mean that students coming from a lower socioeconomic background can be neglected in the climate change education campaign. Second, the present findings indicate that climate change knowledge efficacy mediates the positive influence of science literacy on Filipino youth's energy conservation behaviors at home. Therefore, science and environmental education policies and programs should not only focus on teaching students about the basic knowledge about environmental issues but should also carefully utilize strategies that aim to increase students' belief about their individual and collective capacity to act and contribute to solving climate-related problems. This can be done by adapting the action competence approach in environmental education (see Jensen & Schnack, 1997), which utilizes teaching and learning strategies that highlight the importance of encouraging students' autonomy and efficacy to create targeted solutions to environmental problems. Contrary to the traditional approach in environmental education which focuses on knowledge and behavior at the individual level, the action competence approach emphasizes the social and political contexts allowing students to appreciate potential actions through critical thinking. Such an approach can also help students realize their capabilities to actively participate in the change process as competent individuals in a democratic space. For instance, assigning students with activities that aim to reduce energy use (e.g., unplugging appliances when not in use or turning the lights off when leaving the room) can be a good classroom activity in a traditional educational approach. However, this might be a futile attempt to truly teach students the essence of environmentalism if there is a lack of emphasis on helping them realize their autonomy to decide and act against climate change, and on improving their belief in their ability to make a change as an individual and as a collective. Third, teachers play a key role in ensuring concern for the environment and engagement among the youth. Improving teachers' climate change knowledge and skills can be achieved by providing more effective training for all teachers in public and private schools in the country. Another potential strategy is to integrate climate change education into the teacher education curriculum to ensure that teachers-in-training develop the necessary knowledge and skills in climate change education before they begin their practice as a professional teacher. Fourth, given the important role of parents in modeling and teaching their children about household energy conservation, it is critical that education and community policies and programs that aim to teach parents household energy conservation practices be implemented. Such policies and programs may focus on providing parents with basic knowledge and strategies on how to communicate the importance of protecting the natural environment and model energy preservation practices. Lastly, the insights in this study derived from the nationally representative data among 15-year old students add to the necessity to further strengthen climate change education efforts in the country as a viable way to spark climate action among Filipino youth. This can be done not only by improving science and environmental education programs but also by utilizing action competence (i.e., improving students' abilities and empowering their beliefs in their capacity to take action in mitigating climate change). In summary, the current study offers meaningful insights that can serve as a basis for climate education programs in the Philippines and the Asia-Pacific region.

Data Availability Statement. The data can be accessed from the OECD Program for International Student Assessment (PISA) 2018.

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