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Analyzing Literacy on Weather-Related Hazards and Risks among Students of an Eastern Mediterranean Region

Katerina Papagiannaki [1,*], Kyriaki Makri [1,2], Vassiliki Kotroni [1] and Konstantinos Lagouvardos [1]

[1] National Observatory of Athens, Institute for Environmental Research Greece & Sustainable Development
[2] Ministry of Education and Religion, Directorate of Secondary Education A' Athens
* Correspondence: katpap@noa.gr; Tel.: (0030 6977240204)

Abstract: The present study analyzes students' weather-related hazard and risk literacy in Greece, a climate change hotspot region in the Eastern Mediterranean. In this context, we examine the students' level in two core literacy variables, namely knowledge and competency. In addition, we explore how knowledge, attitudes and socio-demographic variables influence students' competencies related to weather and climate risk assessment and adaptability. A questionnaire-based survey was conducted on 474 students aged 12-16. The regression results showed that knowledge significantly affects the level of competency. Self-belief and confidence in science were the most influential among the attitudinal variables. We conclude by discussing educational and behavioural issues highlighted as essential to address with targeted policies and measures in formal education complemented by non-formal educational activities.

Keywords: students literacy; weather-related hazards; Eastern Mediterranean; Greece

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1. Introduction

Over the past two decades, severe weather-related phenomena have had a devastating impact globally, and future predictions are dire [1]. In the Eastern Mediterranean, a region particularly vulnerable to climate change [2], extreme rainfall, floods, droughts, heatwaves, and wildfires have profound societal implications. Papagiannaki et al. [3], who presented an analysis of the temporal and spatial distribution of high-impact weather events in Greece, found that half of the recorded weather-related phenomena were flash floods, which in turn at a percentage of 81% cause medium to high severity impacts in the study region. The urgency to enhance awareness, risk assessment skills, and adaptability is paramount. Scientific literacy is pivotal in bridging knowledge gaps and empowering individuals to navigate climate challenges. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines literacy as the 'ability to identify, understand, interpret, create, communicate, compute, and use printed and written materials associated with varying contexts'. Strengthening scientific literacy in schools can equip students with these essential skills. Studies have shown that school-based disaster education is crucial in reducing the damage caused by natural disasters [4].

Various factors have been studied regarding their contribution or effect on scientific literacy, with some of the most important being knowledge about the scientific subject [5], specific analytical and interpretation skills, personal interest in the topic [6], and educational [7] and family environment [8]. At the same time, personal experiences, consisting of experiential knowledge and social needs, seem to co-shape the literacy level [9]. Furthermore, there is evidence that attitudinal factors such as personal interest in science, science self-efficacy, and instrumental motivation to learn science mediate the effect of traditional educational practices on scientific literacy [10].

As can be seen from the literature, developing scientific literacy is multifactorial, which formal education should seriously consider. As far as natural disasters are concerned, they are an interdisciplinary research subject, as they represent a common field of interest for both the natural

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and social sciences. However, schools' curricula have not yet adopted such a methodological concept [11]. Furthermore, a recent survey on the literacy of teachers in Turkey showed that concerning natural disasters, it was at a high level but at a moderate level in terms of the behavioural dimension, which is considered a component of overall literacy [11]. These findings indicate that the broader school context is often outdated regarding approaches to ensuring adequate literacy with behavioural implications.

Scientific literacy is an increasingly concerning issue to the research and educational community. The number of publications focusing specifically on climate and climate change literacy has increased exponentially in the last two decades, along with the worldwide increase in climate change events [12]. Some studies have focused on environmental literacy [13], natural disaster literacy [14], and even ocean literacy [15]. A few studies examine citizens' weather literacy [16] or focus on literacy aspects of particular climate or weather-related hazards, such as flooding [17]. However, we notice a literature gap regarding the analysis of students' literacy in weather-related hazards and risks, especially in the region of the particularly burdened and vulnerable Eastern Mediterranean.

In light of the existing literature, this study aims to fill this gap, assessing the literacy of students in Greek schools on the issue of weather-related hazards and risks, testing the knowledge and competencies of students and paying particular attention to considering factors related to attitudes, beliefs, the school and family environment and socio-demographic characteristics. We also discuss policy implications about how changes are necessary for traditional formal education and how its scope should expand to address meteorology, weather-related hazards, and risks, also informing for social and geomorphological vulnerabilities at the global and local levels.

2. Materials and Methods

2.1. Research Framework

Our research framework for analyzing weather-related hazards and risk literacy among Greek students (Figure 1) is based on PISA's (Programme for International Student Assessment by OEDC) methodological and conceptual framework. The PISA student questionnaire assesses literacy in science through multiple interrelated elements: the student's background, beliefs, attitudes, feelings, and behaviours [18]. Teaching practices and learning opportunities are mainly addressed to the educational system and are not examined in the context of the present work but only indirectly. Therefore, our research framework conceptualizes the hypothesis that knowledge may positively affect students' competencies and that attitudes and socio-demographic features influence these core literacy variables.

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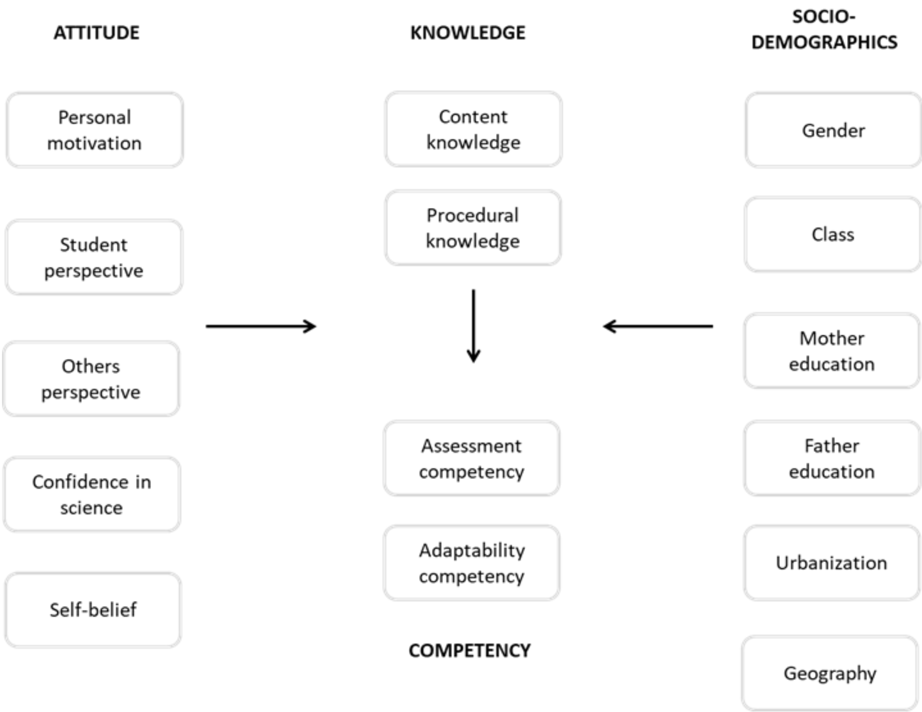

Figure 1. Research framework. It conceptualizes the hypothesis that knowledge may positively affect students' competencies and that attitudes and socio-demographic features influence these core literacy variables.

In the present study, we consider literate the student who understands the basic principles of all aspects of the Earth system that govern meteorological phenomena, knows how to gather and interpret information about weather phenomena, recognizes their hazardous nature and associated risk, and makes scientifically informed and responsible decisions on protection against the weather-related natural hazards. Attitudinal factors and socio-demographic characteristics complete the framework for a deeper understanding of factors influencing student literacy.

2.2. Questionnaire-Based Survey

We constructed an online questionnaire to examine students' literacy in weather-related hazards and risks, targeting secondary school students. The survey was carried out with the permission of the Ministry of Education. The questionnaire was structured around three central themes:

- the student's attitude towards science and applications of meteorology, with a focus on interest in relevant issues and prospects, confidence in the scientific value and personal abilities,
- the student's knowledge, with a focus on content and procedural knowledge, and
- the student's competencies, specifically their ability to use knowledge to assess weather-related hazards and risks and adapt to them.

Socio-demographic characteristics were also recorded. The details and the questionnaire, translated into English, are available as Supplementary Material.

2.2.1. Sample Profile

The conducted survey involved 474 students 12-16 years old from more than 30 public schools. Schools were selected based on geographical criteria, namely the degree of urbanization and geomorphological characteristics, which may be associated with student performance. Regarding urbanization, 38.6% of the participating students live in urban areas, 39.2% in semi-urban areas, and 22.2% in rural areas. Also, 59.1% of students live in lowland areas, 31.0% in islands, and 9.9% in mountainous areas. Among the genders, females are overrepresented, constituting 59.5% of the participating students. Regarding class, 39,0% of students were in the first year of middle school, 25.1% in the second year, 21.9% in the third year, and 13.9% in the first year of high school when the survey was conducted.

2.3. Measures

Survey questionnaire items were closed-ended, and the majority were treated with either a 5-point Likert rating scale or a dichotomous scale (true/false). Table 1 shows the coded variables that emerged from the socio-demographic characteristics and their statistical description. Apart from the categorical geographical variable (lowland, mountainous, island area), the rest are ordinal variables.

Table 1. Coding and statistics of socio-demographic variables (mean (M), standard deviation (SD), min-max).

Socio-demographic variable	Coding	M	SD	Min	Max
Gender	1=female, 2=male	1.41	0.49	1	2
Class	1= middle -1st year, 2= middle -2nd year, 3= middle -3rd year, 4= high -1st year	2.11	1.08	1	4
Urbanization	1= rural, 2= semi-urban, 3= urban	2.16	0.76	1	3
Mother education	1= basic, 2= highschool, 3= technical,	3.19	1.36	1	6
Father education	4=bachelor, 5= master, 6= PhD	3.02	1.34	1	6

2.3.1. Attitude Variables

Multiple items were combined to measure attitude variables to ensure reliable and valid methodological treatment. Principal factor analysis (PFA) was applied to validate each multi-item variable, and Cronbach's alpha (α) was applied to examine the scale's internal reliability. Only items with factor loadings above 0.50 were accepted in PFA to ensure a good fit with the factor [19]. Each attitude variable was then produced by calculating the mean rating of all the accepted items [19]. Scale reliability was considered excellent for α above 0.70 or 0.60 if only a few items (less than 4) were involved [19,20].

Five attitude variables were developed, namely a) personal motivation to engage in the science of meteorology and weather-related hazards, b) instrumental motivation towards a professional future based on the student's own perspective, c) instrumental motivation based on the perspective of others, c) confidence in science value, and d) self-belief, as derived by the student's self-concept and self-efficacy in science and applications.

Regarding *personal motivation*, students were asked to rate 1) their interest in weather-related phenomena and hazards, 2) their enjoyment of observation activities, and 3) the skills they feel they develop through observing weather phenomena. Regarding instrumental motivation related to *student perspective*, students were asked to what extent they 1) would consider a career prospect in the fields examined, 2) felt they could succeed professionally, and 3) felt there was a good career prospect. Regarding instrumental motivation related to *others perspective*, students were asked to what extent they are encouraged, 1) by their parents and 2) by their teachers, to pursue a professional career in these fields. Regarding *confidence in science*, participants were asked 1) how useful they consider scientific knowledge about weather-related hazards and 2) the extent to which scientific research can help citizens protect themselves from those hazards. Finally, regarding *self-belief*, six questions were posed about students' understanding of meteorological concepts and hazards (self-content) and their ability to interpret the effects of weather-related phenomena (self-efficacy).

2.3.2. Knowledge and Competency Variables

Knowledge questions were about either content (13 questions) or procedural knowledge (10 questions). Content knowledge questions deepen on issues related to the occurrence of weather-related phenomena and associated risks in Greece. It was requested, for example, to confirm the correctness of proposals such as that the spread of forest fires is favoured by high humidity (false) or

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choose the correct explanation for the fact that temperature differences cause lateral and vertical air movements. Procedural knowledge questions included weather maps, and the students were invited to answer questions requiring familiarity.

Competency questions focused either on the ability to assess the risk of meteorological and weather-related phenomena (11 questions) or on the ability to adapt to or reduce risk (9 questions). Assessment competency questions asked the student, for example, to evaluate the risk for eventually intense phenomena through the assessment of cloud photographs. Adaptability competency questions examined whether, for example, the student knows of good practices for protection from intense events such as storms, floods, or heatwaves.

The scores of the items were aggregated to generate the continuous variables of *content knowledge*, *procedural knowledge*, *assessment competency*, and *adaptability competency*.

2.3.3. Statistical Methods

Several statistical methods were employed to analyze the survey responses. Descriptive analysis and non-parametric tests were used to check for the distribution of the survey variables and the correlations between them. We used Spearman's correlation to account for variables without normal distribution.

We then performed multiple regression analyses, specifically the stepwise linear regression method, to investigate how student competency related to weather risk assessment and adaptability is affected by attitudes and knowledge. Therefore, two models were examined, one for assessment competency and one for adaptability competency. Two additional models were examined to test the effects of attitudes on knowledge variables. All regression analyses included socio-demographic and geographic characteristics as control variables. For statistical analyses, all the continuous variables of attitude, knowledge, and competency were normalized to range between 0 and 1. The level of confidence in all statistical analyses was 95%.

3. Results

3.1. Descriptive and Correlation Analyses

Table 2 presents the statistical description of attitude variables and the associated items, the scale reliability of variables, and item factor loadings where applicable (i.e., at least three items involved).

Table 2. Statistics (mean (M), standard deviation (SD), min-max) of attitude variables. n = 474 for all items and variables.

Attitude variable	Items	M	SD	Min	Max	Cronbach's alpha	Factor loadings
Personal motivation		2.85	0.87	1	5	0.70	
	interest	2.97	1.01	1	5		0.66
	enjoyment	2.66	1.17	1	5		0.67
	skills development	2.92	1.14				0.51
Student perspective		2.35	0.79	1	5	0.62	
	career consideration	1.80	1.02	1	5		0.57
	professional success	2.33	1.09	1	5		0.59
	good career prospect	2.90	1.04	1	5		0.50
Others perspective		1.76	0.94	1	5	0.73	
	parents	1.72	1.03	1	5		n/a
	teachers	1.80	1.09	1	5		n/a
Confidence in science		3.92	0.92	1	5	0.67	
	useful	3.87	1.09	1	5		n/a
	helpful	3.97	1.03	1	5		n/a
Self-belief		2.68	0.75	1	5	0.81	
	understanding of meteorological concepts	2.55	0.96	1	5		0.68

	understanding of associated risks	3.25	1.03	1	5		0.64
.	interpretation of extreme events increase	2.34	0.96	1	5		0.61
	identification of societal impacts	2.48	0.99	1	5		0.70
	explanation of GHG and heatwaves	2.76	1.16	1	5		0.63
	discussion of policies & measures	2.68	1.18	1	5		0.59

Note: Scale reliability (Cronbach's alpha, α) and construction (item factor loadings) are provided if applicable (i.e., at least three items (Robinson, 2018)). n/a: not applicable.

To compare performance between attitude, knowledge, and competency variables, distributions of the normalized (at 0-1 range) measures are shown in Figure 2. Among the variables of attitude, *confidence in science* has the highest performance, and *personal motivation* and *self-belief* have a moderate performance. In contrast, *student perspective* and especially *others perspective*, are rated much lower. Knowledge variables show relatively high performance. *Content knowledge* has the lowest variability, indicating that respondents have more consistent performance in questions on understanding weather-related hazards and associated risks in Greece. Both competency variables show relatively low variability; however, *adaptability competency* scores much higher than *assessment competency*.

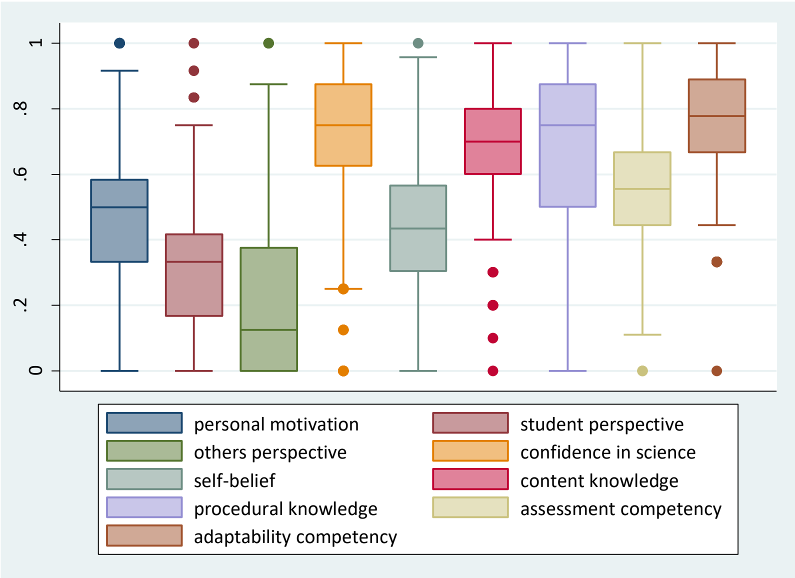

Figure 2. Box plots of the attitude, knowledge, and competency variables. Normalized measures at a 0-1 range are shown.

Table 3 shows the statistically significant correlations (Spearman's rho, p<0.05) between all the examined variables, indicating that demographic attributes such as gender and urbanization in the areas where students live are not generally associated with the level of attitude, knowledge, and competency variables.

Table 3. Correlations (Spearman's rank coefficient, rho) between the examined variables.

	class	**gender**	**urbanization**	**mother education**	**father education**	***personal motivation***	***student perspective***	***others perspective***	***confidence in science***	***self-belief***	***content knowledge***	***procedural knowledge***	***assessment competency***	***adaptability competency***
class	1.00													
gender		1.00												

urbanization	-0.14	0.11	1.00											
mother education			0.19	1.00										
father education			0.13	0.62	1.00									
personal motivation						1.00								
student perspective	-0.17					0.57	1.00							
others perspective	-0.22			-0.09	-0.10	0.33	0.50	1.00						
confidence in science		-0.09				0.57	0.38	0.11	1.00					
self-belief				0.11	0.12	0.62	0.48	0.24	0.49	1.00				
content knowledge	0.15		0.09	0.15		0.20		-0.10	0.24	0.19	1.00			
procedural knowledge	0.13					0.29			0.24	0.26	0.25	1.00		
assessment competency	0.16					0.21	0.11		0.20	0.27	0.24	0.31	1.00	
adaptability competency				0.09		0.20			0.22	0.19	0.18	0.30	0.21	1.00

Note: Only statistically significant results are provided ($p < 0.05$). The coding of the rest of the variables is shown in Table 2.

The relationship between gender and *confidence in science* is the exception, showing females with higher confidence, although the statistically significant correlation is weak (rho= -0.09). Regarding the parents' educational level, it was found to be related positively to *others perspective* (rho= 0.09-0.10), i.e., to the instrumental motivation through the encouragement by parents and teachers. It is also related to *self-belief* (rho= 0.11-0.12), which was found to be reinforced by the more educated parents. None of the correlations are high enough to raise concerns for the subsequent regression analyses [21].

3.2. Multiple Regression Analyses

Table 4 provides the results of the multiple regression analyses performed to assess the effects of attitude, knowledge, and socio-demographic variables on competency variables. Furthermore, Table 5 presents the results of two additional regression models that test the effects of attitudes and socio-demographics on knowledge variables.

Table 4. Results of multiple regression analyses performed to assess the effects of knowledge, attitudes and socio-demographic variables on competency variables. Only predictors having significant coefficients ($p<0.05$) are shown.

Variable	Assessment competency			Variable	Adaptability competency		
	B	**SE B**	**β**		**B**	**SE B**	**β**
self-belief	0.17***	0.04	0.18	*confidence in science*	0.10***	0.03	0.15

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content knowledge	0.14**	0.05	0.13	*content knowledge*	0.08*	0.04	0.09
procedural knowledge	0.16***	0.03	0.22	*procedural knowledge*	0.16***	0.03	0.26
class	0.02**	0.01	0.12	gender	-0.03*	0.01	-0.11
				geography (lowland vs island)	0.04**	0.01	0.12
_cons	0.25***	0.04		_cons	0.51***	0.04	
Fit statistics	F(4, 469) = 24.86***	Adj. R2 = 0.17	VIF = 1.10	Fit statistics	F(5, 468) = 20.25***	Adj. R2 = 0.17	VIF = 1.09

Note: β are standardized beta coefficients. Statistical significance, p-value, is symbolized as * p <0.05, **p < 0.01, *** p <0.001.

Table 5. Results of multiple regression analyses performed to assess the effects of attitudes and socio-demographics on knowledge variables. Only predictors having significant coefficients (p<0.05) are shown.

Variable	**Content knowledge**			**Variable**	**Procedural knowledge**		
	B	**SE B**	**β**		**B**	**SE B**	**β**
others perspective	-0.08*	0.03	-0.10*	*personal motivation*	0.25***	0.07	0.21
confidence in science	0.18***	0.04	0.23***	*others perspective*	-0.17***	0.05	-0.16
self-belief	0.10*	0.05	0.11*	*self-belief*	0.23**	0.07	0.17
class	0.02**	0.01	0.14**				
urbanization	0.02*	0.01	0.10*				
mother education	0.01*	0.01	0.09*				
_cons	0.38***	0.04		_cons	0.50***	0.03	
Fit statistics	F(6, 467) = 12.36***	Adj. R2 = 0.13	VIF = 1.20	Fit statistics	F(3, 470) = 19.88***	Adj. R2 = 0.11	VIF = 1.50

Note: β are standardized beta coefficients. Statistical significance, p-value, is symbolized as * p <0.05, **p < 0.01, *** p <0.001.

F values for the models are significant at the 0.1% level, indicating a very good fit of the data. The adjusted R square is 17% for the competency models and 11%-13% for the knowledge models. To assess multicollinearity, we computed the variance inflation factor (VIF) scores below the accepted cut-off of 10 [22], ranging from 1.09 to 1.50.

Regression results are displayed graphically in Figure 3 and 4 to help interpret and compare the effects on the dependent variables. According to the model results, knowledge significantly affects the level of competencies. Both *assessment competency* and *adaptability competency* were found to be positively affected by *content knowledge* (0.14, p<0.01 and 0.08, p<0.05, respectively) and especially by *procedural knowledge* (0.16, p<0.001 and 0.16, p<0.001, respectively). Among the variables of attitude, *self-belief* was found to have a significant positive effect on *assessment competency* (0.17, p<0.001), and *confidence in science* was found to have a significant positive effect on *adaptability competency* (0.10, p<0.001).

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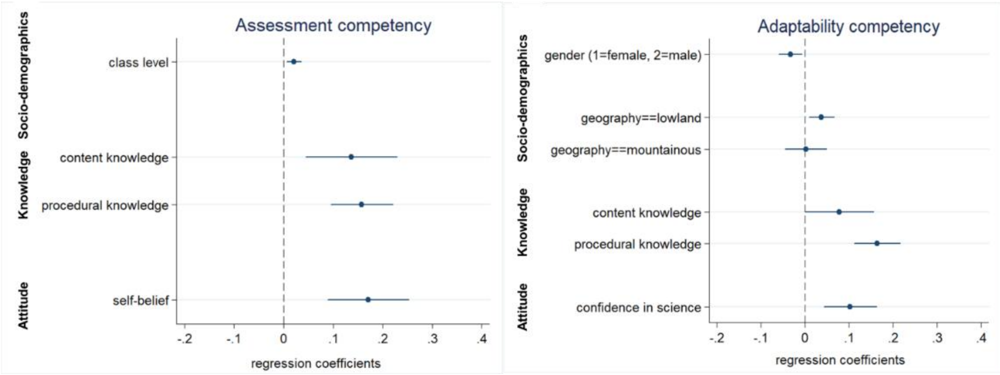

Figure 3. Graphical representation of regression results for competency models.

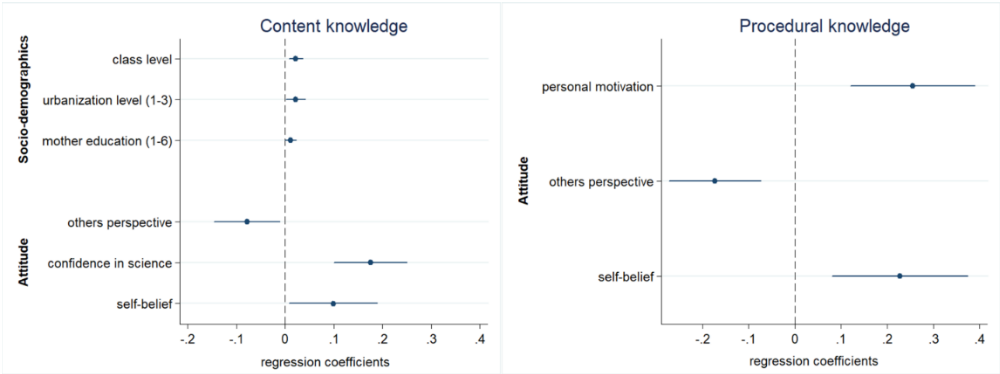

Figure 4. Graphical representation of regression results for knowledge models.

Personal and instrumental motivation (*student perspective and others perspective*) were not found to have significant effects on competency variables. However, they were found to have a significant effect on knowledge performance. Of particular interest is that while *personal motivation* was found to have a positive effect on the level of *procedural knowledge* (0.25, $p<0.001$), motivation given through *others perspective* (i.e., encouraged by parents and teachers) was found to have a negative effect on both *content knowledge* (-0.08, $p<0.05$) and *procedural knowledge* (-0.17, $p<0.001$). *Content knowledge* was also found to be positively and comparably strongly affected by *confidence in science* (0.18, $p<0.001$), as well as by *self-belief* (0.10, $p<0.05$), which also affected *procedural knowledge* (0.23, $p<0.01$). It should be noted that *self-belief* was found to positively affect dependent variables in three of the four models, showing that it is a critical factor in student literacy.

In what concerns the socio-demographic variables, the class level has a positive but weak effect on *assessment competency* (0.02, $p<0.01$) and an insignificant effect on *adaptability competency*, which was found to be slightly influenced by gender (-0.03, $p<0.05$) and geographical features (0.04, $p<0.01$). In particular, males are associated with lower *adaptability competency* and lowland areas are associated with increased *adaptability competency* relative to the islands.

The effects of parents' education were insignificant within the models, except for a positive but weak effect of mother education on *content knowledge* (0.01, $p<0.05$). Similarly, urbanization was not found to affect competencies, while its positive effect on *content knowledge* was weak (0.02, $p<0.05$).

4. Discussion

Results indicate, on average, low attitude variable ratings (except for confidence in science) compared to knowledge and competency scores, which are moderate to high. Students' overall performance in the two core literacy variables, knowledge and competency, indicates that they possess relatively good understanding and skills despite lacking engagement or self-confidence. Furthermore, results show that knowledge is a critical driver of competency. Confirming our hypothesis that knowledge variables positively affect competencies is crucial for the validity of our method and the robustness of our discussion.

The low ratings in personal and instrumental motivation suggest that students are currently not highly engaged, personally interested or motivated by others towards meteorology and learning about weather-related phenomena, their hazardous nature and associated risks. This disconnect shows that the educational system in Greece imparts knowledge through structured curricula but fails to inspire or motivate students personally.

According to the self-determination theory [23], when people lack personal inspiration or intrinsic motivation, their engagement may suffer, leading to a disconnect between knowledge acquisition and self-belief. In support of this theory, the regression results suggest that attitudes may affect literacy levels. First, higher self-belief, i.e., confidence in their ability to comprehend and interpret weather-related hazards and risks, positively affects knowledge levels (content and procedural knowledge) and the ability to assess the risk of weather-related phenomena (assessment competency). Second, personal motivation activates the acquisition of procedural knowledge, which requires familiarity with more technical approaches, such as interpreting and comprehending weather and risk maps. Third, students with higher confidence in science better understand weather-related phenomena and associated risks (content knowledge) and have a higher ability to adapt and take measures to reduce risk (adaptability competency).

Contrary to previous findings regarding attitudes, the perspective adopted by third parties (parents, teachers) even negatively affects students' literacy, especially on the foundation of knowledge. We must highlight, however, that self-belief is related to the parents and the school environment and has a strong positive effect on most of the literacy variables. Previous literature has suggested that parents' beliefs can shape students' motivation, achievement, and career choices in STEM fields (science, technology, engineering, and mathematics [24] and that the school environment can influence students' self-efficacy and self-identity [25]. At the same time, our results show that self-belief, personal motivation, and personal perspectives also have positive and relatively strong correlations. The above findings suggest that the interest of parents and educators may be more critical in enhancing the children's self-confidence, which in turn fosters the student to become literate and pursue knowledge. The findings also imply that students may perceive instrumental motivation as pressure to meet expectations rather than genuinely engaging in seeking knowledge on a subject. Relevant studies have noted such behavioural issues and discussed how acknowledging students' intrinsic interests and providing autonomy can help create a positive learning experience [26].

According to the results, sociodemographics do not significantly affect knowledge and competencies scores overall, mainly when attitude parameters are considered. More specifically, gender does not influence educational outcomes. It is, however, related to confidence in science, which is higher for females, in line with previous studies on the subject [27]. In addition, living in more urban and lowland areas, as well as the mother's higher educational level and the student's higher class level, affect the knowledge and skills to a very small extent. In other words, attitudes emerge as more influential overall.

5. Conclusions

The findings of this study highlight the critical role that knowledge about weather-related phenomena, hazards and risks plays in enhancing students' competencies. Furthermore, despite the relatively low levels, attitudes have been shown to affect the core literacy variables, namely knowledge and competencies. The findings suggest that family and teachers fail to motivate the pursuit of knowledge and skills; however, they appear significant in reinforcing self-belief, which is one of the critical factors in boosting literacy levels. The high confidence in science among students shows that they recognize the importance and value of scientific knowledge. This recognition likely drives their performance in knowledge and competencies, even if their personal interest and motivation are low. Confidence in science can be fostered by family environments or educational

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practices that emphasize the critical role of science in addressing real-world problems, such as weather-related hazards.

These results suggest several implications for education policy. Educational programs should prioritize strategies that boost intrinsic motivation and self-belief among students. Enhancing literacy in meteorology requires integrating more engaging, real-world applications of meteorological concepts into the curriculum and providing professional development for teachers to foster student motivation and enthusiasm. Additionally, increasing parental and community involvement through initiatives highlighting the importance of science education can provide students with the external support needed to enhance their personal and instrumental motivation. Furthermore, non-formal and informal education, such as extracurricular activities and community programs, are essential and should be promoted by central education policies and adopted by school units. These initiatives can make learning more dynamic and relevant, helping to develop knowledgeable, highly motivated, and confident students ready to tackle weather-related challenges, thereby improving overall literacy in this critical field.

Supplementary Materials: The link to be added if accepted

Author Contributions: Conceptualization, K.M., V.K., K.P., K.L.; Methodology, K.P., V.K., K.M., K.L.; Data Curation, K.P.; Writing – Original Draft Preparation, K.P.; Writing – Review & Editing, V.K., K.M., K.L..; Supervision, V.K.; Project Administration, V.K.; Funding Acquisition, V.K..

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Data Availability Statement: These are not available data; they concern non-adults, and the Ministry of Education has permitted the authors to use them only for this analysis.

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References

1. Lee, H.; Romero, H.; Core writing team IPCC. IPCC 2023: Climate change 2023 Synthesis report. In Contribution of working groups I, II and III to the Sixth Assessment Report, Intergovernmental Panel on Climate Change, Geneva, Switzerland, 2023; 35–115. https://doi.org/10.59327/IPCC/AR6-9789291691647
2. Hochman, A.; Marra, F.; Messori, G.; Pinto, J. G.; Raveh-Rubin, S.; Yosef, Y.; Zittis, G. Extreme weather and societal impacts in the eastern Mediterranean, Earth Syst. Dynam 2022; 13, 749–777. https://doi.org/10.5194/esd-13-749-2022
3. Papagiannaki K.; K. Lagouvardos, K.; Kotroni, V. A database of high-impact weather events in Greece: a descriptive impact analysis for the period 2001–2011, Natural Hazards and Earth System Sciences 2013; 13, 727–736. https://doi.org/10.5194/nhess-13-727-2013
4. Zhu, T.T.; Zhang, Y.Y. An investigation of disaster education in elementary and secondary schools: evidence from China. Nat Hazards 2017; 89, 1009-1029. https://doi.org/10.1007/s11069-017-3004-2
5. Cheng, SC.; Hwang, GJ.; Chen, CH. Fostering students' scientific literacy by reflective questioning: An identification, summarization, self-reflective questioning, and application (ISSA)-based flipped learning approach. Educ Inf Technol 29 2024; 7081–7104. https://doi.org/10.1007/s10639-023-12121-9
6. Setyowati, A.P.; Gunarhadi, G.; Musadad, A.A. Profile and Factors Influencing Students' Scientific Literacy, Journal of International Conference Proceedings; 2022; 5(1), 314-323. http://dx.doi.org/10.32535/jicp.v5i1.1481
7. Kelp N.C.; McCartney M.; Sarvary MA.; Shaffer JF.; Wolyniak MJ. Developing Science Literacy in Students and Society: Theory, Research, and Practice. Journal of Microbiology & Biology Education 2024; 24, 15-31. https://doi.org/10.1128/jmbe.00058-23
8. Cabello, V.M.; Véliz, K.D.; Moncada-Arce, A.M.; Irarrázaval García-Huidobro, M.; Juillerat, F. Disaster Risk Reduction Education: Tensions and Connections with Sustainable Development Goals. Sustainability 2021; 13, 10933. https://doi.org/10.3390/su131910933

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 5 July 2024 doi:10.20944/preprints202407.0521.v1

9. Pan WL.; Fan R.; Pan W.; Ma X.; Hu C.; et al. The role of climate literacy in individual response to climate change: evidence from China. Journal of Cleaner Production 2023, 405 https://doi.org/10.1016/j.jclepro.2023.136874
10. Ma, Y.; The Effect of Inquiry-Based Practices on Scientific Literacy: the Mediating Role of Science Attitudes. Int J of Sci and Math Educ 2023; 2045–2066. [CrossRef]
11. Türker, A.; Sözcü, U. Examining natural disaster literacy levels of pre-service geography teachers. Journal of Pedagogical Research 2021; 5(2), 207-221. https://doi.org/10.1007/s10763-022-10336-9
12. Suhaimi, N.; Mahmud, S.N.D. A Bibliometric Analysis of Climate Change Literacy between 2001 and 2021. Sustainability 2022; 14, 11940. https://doi.org/10.3390/su141911940
13. Maurer, M.; Bogner, F.X. Modelling environmental literacy with environmental knowledge, values and (reported) behavior. Studies in Educational Evaluation 2020; 65. https://doi.org/10.1016/j.stueduc.2020.100863
14. Cerulli, D.; Scott, M.; Aunap, R.; Kull, A.; Pärn, J.; Holbrook, J.; Mander, Ü. The Role of Education in Increasing Awareness and Reducing Impact of Natural Hazards. Sustainability 2020; 12, 7623. https://doi.org/10.3390/su12187623
15. Koulouri, P.; Mogias, A.; Mokos, M.; Cheimonopoulou, M.; Realdon, G.; Boubonari, T.; Previati, M.; Formoso, A. T.; Kıdeyş, A. E.; Hassaan, M. A.; Patti, P.; Korfiatis, K.; Fabri, S.; & Juan, X. Ocean Literacy across the Mediterranean Sea basin: Evaluating Middle School Students' Knowledge, Attitudes, and Behaviour towards Ocean Sciences Issues. MEDITERRANEAN MARINE SCIENCE 2022; 23(2), 289–301. https://hdl.handle.net/11511/97301
16. Fleischhut, N.; Herzog S. M.; Hertwig R. Weather Literacy in Times of Climate Change. Wea. Climate Soc 2020; 12, 435–452. https://doi.org/10.1175/WCAS-D-19-0043.1
17. Ramasubramanian, M.; Allan, J. N.; Retamero, R. G.; Jenkins-Smith, H.; Cokely, E. T.. Flood Risk Literacy: Communication and Implications for Protective Action. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2019; 63(1), 1629-1633. https://doi.org/10.1177/1071181319631504
18. OECD, 2022. PISA 2022 Assessment and Analytical Framework. Available online https://www.oecd-ilibrary.org/sites/9b4831be-en/index.html?itemId=/content/component/9b4831be-en#section-d1e17410-faf300e918. (accessed 1 June 2024).
19. Robinson M. A. Using multi-item psychometric scales for research and practice in human resource management. Human Resource Management 2018; 57(3), 739-750.
20. Nunnally, J.C. and Bernstein, I.H. The Assessment of Reliability. Psychometric Theory 1994; 3, 248-292.
21. Gujarati N.D. Basic Econometrics, 4th Edition, McGraw-Hill Companies NY, USA, 2004.
22. Hair, J.; Black, W.; Babin, B.; Anderson, R.; Tatham, R.L. Mutivariate Data Analysis, 6th Edition, Pearson Prentice Hall, Upper Saddle River NJ, USA, 2006.
23. Manninen, M.; Dishman, R.; Hwang, Y.; Magrum, E.; Deng, Y.; Yli-Piipari, S. Self-determination theory based instructional interventions and motivational regulations in organized physical activity: A systematic review and multivariate meta-analysis, Psychology of Sport and Exercise 2022; 62. https://doi.org/10.1016/j.psychsport.2022.102248
24. Šimunović, M.; Babarović, T. The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research. Soc Psychol Educ 2020; 23, 701–719. https://doi.org/10.1007/s11218-020-09555-1
25. Shı, Y.; Ko, Y. C. A Study on the Influence of Family and School Psychological Environment on Academic Self-Efficacy and Self-Identity of English Education Major University Students. Participatory Educational Research 2023; 10(1), 106-121. https://doi.org/10.17275/per.23.6.10.1
26. Çelik, O. Academic motivation in adolescents: the role of parental autonomy support, psychological needs satisfaction and self-control. Frontiers in Psychology 2024; 15. https://doi.org/10.3389/fpsyg.2024.1384695
27. Karakolidis, A.; Pitsia, V.; Emvalotis, A. Examining students' achievement in mathematics: A multilevel analysis of the Programme for International Student Assessment (PISA) 2012 data for Greece. International Journal of Educational Research 2016; 79, 106-115. https://doi.org/10.1016/j.ijer.2016.05.013