Risk Literacy and Environmental Education: Does Exposure to Academic Environmental Education Make a Difference in How Students Perceive Ecological Risks and Evaluate Their Risk Severity?

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Abstract: Developed understanding of environmental problems, consequences, and risks constitutes a core target of environmental education (EE). Ecological risks (ERs) are inherently complex, interconnected, and subject to perceptual biases. To explore whether an exposure to EE in academia improves ER literacy, we compared ER perception of students who were exposed to EE (“EE majors”) with students who were not (“non-EE majors”). Drawing on the psychometric paradigm from risk perception research, we compared ER perception between the two groups to identify whether the students perceive, appraise, and prioritize ERs differently, and whether they provide different reasons for their decisions and evaluations. We found significant differences in the perception of overall severity of environmental problems, especially of the less “popular” and familiar ones, characterized by global, complex, and extensive consequences. Compared to non-EE majors, EE majors perceived most ERs as more certain, personal, and temporally and spatially close. Risk prioritization and the reasons given for these choices also differed; EE major students’ choices were mostly guided by holistic reasons, whereas the non-EE major students’ explanations were more anthropocentric or one-dimensional. The discussion focused on the importance of ER literacy in reducing misconceptions of environmental problems and on developing an informed assessment of their severity.

Keywords: ecological risk perception; environmental risk perception; environmental education in higher education

1. Introduction

In the deteriorating state of the environment, a significant and immediate behavioral change is required. A prerequisite for people to be motivated to make behavioral changes is to recognize and acknowledge that there is a problem, and that it is severe. This does not necessarily guarantee a behavioral change, but it is one of the necessary conditions [1]. Therefore, it is crucial to understand whether and how people understand and evaluate ecological problems and what factors influence the perception and evaluation of ecological risks (ERs).

This question leads us to the extensively studied field of risk perceptions. One of the broad generalizations produced by studies that examine how people evaluate and prioritize everyday life risks such as terrorism, health, technology, or accidents is that risk assessment is subjective and biased (for an extensive review, see Slovic, 2016 [1]). This is expressed in misconceptions about the severity of problems—an overestimation of relatively non-significant and rare risks and an underestimation of
significant problems. Another widely accepted conclusion is that there is an expert/non-expert gap in risk assessment, and that professional knowledge is important for realistic risk assessment [2–4].

In recent years, more research attention has been given to the perceptions of ecological risks, especially in the context of climate change [5–9]. In this context, too, studies have found that many misperceptions and misconceptions exist about climate change and global warming that are common among ecologically illiterate people.

Our study is based on the premise that environment-related academic education, which, by definition, is designed to impart an elementary understanding of environmental problems, should generate more informed non-biased ER assessments. Moreover, higher education institutions are expected to increase their commitment to preparing environmentally literate graduates who are willing to function as influential environmental citizens and professionals in society (see, for example, [10,11]). Hollweg et al. (2011, pp. 2–3) defined the environmentally literate person as “someone who, both individually and together with others, makes informed decisions concerning the environment; is willing to act on these decisions to improve the well-being of other individuals, societies, and the global environment; and participates in civic life” [12]. Our point of departure in this study is that ER literacy is valuable to investigate because it is included in the wider concept of environmental literacy. As such, ER-literate individuals are more capable of making informed decisions concerning the environment and are willing to act to improve the environment and their own and others’ well-being.

In this study we expanded the investigation of ER perception and went beyond the perception of climate change, which is relatively more studied, and instead studied the perception of a wider range of ecological problems that are not always covered by the media, such as the loss of biodiversity, loss of open spaces, various sources of pollution (air, soil, water), water scarcity, population growth, and more. We adopted the psychometric paradigm as our framework—an approach that integrates risk assessment and cognitive psychology. The psychometric paradigm offers a method for exploring how individuals or groups perceive hazards and visualize them as a cognitive map. In this way we were able to illustrate how various ERs are perceived and interpreted by people who were exposed to environmental education (EE) versus people who lack such a professional background (non-EE).

In the next section, we review basic definitions of risk perception, introduce the psychometric paradigm, and explain the relevance of its use as a theoretical framework in this study (Section 1.1). Next, we narrow down the review of risk perception in general to ecological risk perception and explain why we believe that risk literacy and ER perception are key parts of environmental literacy (Section 1.2). In the following (Section 1.3), we focus on reviewing the role of ER perception and EE in higher education institutions. We end this chapter with our research rationale—the expected relationship between exposure to academic EE and ER assessment according to this framework, the research questions, and hypotheses (Section 1.4).

1.1. Definition of Risk Perception and the Factors Known to Influence Risk Assessment

There are various definitions of risk perception. For example, Sjöberg (1999) defined it as the subjective evaluation of the nature and severity of a danger [13]. According to Asbrock and Fritsche (2013), threat perception is the perception that something aversive is going to happen or the feeling that the satisfaction of one’s basic needs or goals may be hampered [14]. Slovic (1999) notes that risk is subjective, “from the initial structuring of a risk problem, to deciding which endpoints or consequences to include in its analysis, identification and estimation of exposure, and so on” ([15], p. 690). In his analysis of environmental risks in the age of the Anthropocene, Heurtebise (2017) defines risks as “the irruption of a potential threat to the ‘stability’ of human society, something disrupting the social ‘order’” (p. 4) [16]. As such, risk perception reflects collective attitudes, beliefs, or experiences, forming a sociocultural interpretation of risks.

At this point it is important to acknowledge that there are several branches of risk assessment, that is, the realistic approach. In his book "Risk Society", Beck and Kolankiewicz (2000) argue that risks are inevitable results of the industrial hazards and damages brought by modernity [17]. Their concept
has been criticized for being too objectivist [18]. Heurtebise (2017) discusses these approaches in detail and demonstrates how each, in turn, contributes to the understanding of the complexity of risk assessment and perception [16].

Many factors have been shown to influence people’s perceptions of severity, from demographic and sociological factors (for a review, see [16,19]), to personality or psychological factors [20–22] to risk attributes (for a comprehensive review, see [1]). In the present study, we focused on the last category of factors, namely, the perceived risk attributes that are often cited as strong predictors of risk perception and an engagement in protective or preventive action [1,19]. These risk attributes are: (1) the perceived certainty of risk realization [23–26] (2) the perceived imminence of the risk [23–25,27]; (3) the perceived spatial proximity, which is the perceived geographic distance or localization of the risk relative to the person [28]; (4) the perceived potential for personal harm [24,25]; (5) the perceived predictability of the risk [24,25]; (6) the intensity of emotion that arises at the thought of the risk, which was found to be one of the strongest predictors of risk perception—this specifically refers to the level of the negative emotion, that is, anger, sadness, fear, and disgust, among others [29,30]; and (7) the media attention to the risk that, in light of today’s media-dominated world, is considered to be relevant for risk perception [24,25]. These seven risk attributes were used as predictors of the perceived severity of ERs.

Risk assessment often involves not only evaluating, but also prioritizing the risks for the reason that evaluation and addressing risks never occur in a vacuum. In any given socio-political context, at any given moment, an individual (or a society) is faced with multiple problems that may simultaneously threaten its existence or well-being. Here too, the degree of importance assigned to risks may be prone to cognitive biases that are influenced by many sociocultural factors, such as cultural background, social status or media exposure [16]. Nonetheless, as threat mitigation requires the investment of vast resources such as time, money, convenience, and more, on both personal and government levels, and because there is a finite pool of such resources, it is necessary to prioritize [31–33].

Our study draws on the psychometric paradigm, used as our theoretical framework. This paradigm was originally developed for the purpose of studying public attitudes towards risks. It has been widely used to assess laypeople’s in-depth risk perceptions by using a multivariate scaling method. It produces a perceptual, cognitive map of the risks according to a set of various (perceived) risk attributes [28]. The risk attributes, described in the previous section as “the factors known to influence risk assessment” serve to distinguish between individuals and groups and enable comparison between them [34] (For an extensive updated review, see [35]). These perceptual maps not only explain variations between the perceptions of different risks by individuals or groups, but also enable assessing the extent to which the attribute dimensions predict key outcomes, such as judgment of risk severity and risk prioritization [36–38].

The relevance of this paradigm in the present study was twofold: First, this approach explained variations between the perceptions of different risks. It did so by identifying the (perceived) characteristics of the risk that most strongly influence overall risk assessment [39]. Understanding which of the perceived characteristics determined overall risk assessment may indicate which of the risk attributes should be emphasized in EE or communication efforts. Second, in the aggregated analysis, this approach explained variations between the perceptions of different groups of people [35]. In the present case, the two groups were EE versus non-EE students. The emerging perceptual maps, reflecting differences in their shared beliefs and (mis)conceptions, may indicate the effect of exposure (or lack of exposure) to EE during their academic studies. Understanding the differences in ER perception (i.e., the perceived ER attributes and the interrelationship among the ERs) between ecologically literate versus ecologically illiterate students may point to the added value, if any, of students’ exposure to ecological content in academia.

1.2. Environmental Education, Risk Literacy, and ER Assessment

In 2010, an exhaustive article summarizing the goals of EE in the 21st century was published as an introduction to a special issue of the Journal of Environmental Education [40]. The article cited the
UNESCO Tbilisi Declaration (1977) [41] as the strongest voice that focused on EE objectives, which were to strengthen the understanding of environmental problems and to find a solution for them. In that paper, Hungerford described his efforts over the years to promote EE as an interdisciplinary endeavor aimed at “helping learners gain the knowledge and skills that would allow them to understand the complex environmental issues facing society, as well as the ability to deal effectively and responsibly with them” (p. 2). These stated goals actually encompass the proficiencies required for making informed decisions regarding ecological problems and risks. In his paper, Hungerford went on to quote Volk and McBeth’s (1997) recommendation based on a report about environmental literacy in the United States, “[I]t would appear more productive in our society to teach for informed and capable decision makers, who possess the knowledge to foresee consequences of current practices and behaviors from both scientific and societal perspectives, who have the skills to weigh and evaluate the desirability of those consequences” (p. 3) [42].

Riechard (1993) was one of the first scholars to advocate the need to incorporate risk literacy into the curriculum of EE [43]. He specifically emphasized that, for the attainment of a risk-literate society, an accurate risk perception skill is crucial, and called it “the missing link” in EE. Later publications acknowledged the importance of risk literacy in the wider context of scientific literacy—Zint (2001) [44], Covitt et al. (2005) [45], and Stevenson et al. (2014) [6] focused on the importance of risk competence and educating the youth to develop young people into scientifically informed citizens. Schenk et al. (2019) [46] also argued that risk assessment is a relevant content for almost all aspects of science education and reviewed a variety of ways in which it can be incorporated. Zint (2001) [44], and Hansen and Hammann (2017) [39] list the required skills for developing risk literacy, which include critical thinking, systems thinking, interpreting probabilities, and proficiency in making risk comparisons. Given the importance of risk competence and the expected skills from exposure to environmental content, we believe it is important to examine whether exposure to EE (i.e., enrollment in some EE program) enables better-informed evaluations of environmental risks.

1.3. Ecological Risk Assessment and EE in Higher Education Institutions

Higher education plays an extremely important role in developing environmentally literate people who can better manage in the era of ecological crisis. Curriculum and study design may enable students to access basic knowledge on environmental issues, which may lead to increased awareness and, therefore, an ecologically sound society [47,48]. Duan and Fortner (2010) [49] refer to the role of EE in higher education more specifically and claim that because modern EE deals with global risks to environment and people, it is important to study students’ awareness to and perception of ERs. They also maintain that focusing research on EE in higher education institutions is important as “college students will be the leaders of society or decision makers of institutions, and their concerns and opinions about environmental risks are valuable for environmental managers” ([49], p.2).

Many studies have been done to evaluate the effect of enrollment in various types of EE programs on students’ environmental literacy, in general [50,51] or on selected components of environmental literacy in particular [52–54]. Fewer studies have addressed students’ attitudes towards, or awareness of, various aspects of risk management [49,55,56] and they conclude that, in general, environmental risk literacy is limited compared with other general environmental issues among university students.

To the best of our knowledge, the environmental risk perception of higher education institution students that were exposed to EE compared to non-EE students has not yet been examined. This study aims at filling this gap, not only by examining the differences in risk assessments of EE versus non-EE students, but also by endeavoring to discover whether there is a difference in the considerations leading to the different assessments.

1.4. Study Rationale, Goals, and Hypotheses

The rationale of the research is based on the assumption that academic EE provides better tools for an informed assessment of environmental problems. However, because risk assessment is influenced by
so many psychological factors and cognitive biases (other than knowledge), beyond checking whether EE students are more aware of environmental risks than non-EE students, we aimed at deconstructing the (perceived) risk attributes that determine risk assessment, while comparing different types of ecological risks.

In light of this, this study answers the following questions: (1) Do students who enroll in environment-related programs perceive ERs as more severe compared to students who enroll in non-environmental programs? (2) Do they make different choices when they are required to prioritize ERs? (3) Are the reasons and considerations for making their choices, evaluations, and prioritizations different? And finally, (4) which of the environmental risks is perceived most differently by EE versus non-EE students?

By combining quantitative with qualitative approaches and analyses, we tested the following hypotheses:

**Hypothesis 1 (H1).** EE students will evaluate anthropogenic ERs as generally more severe than non-EE students.

**Hypothesis 2 (H2).** EE students will perceive most risks as more certain, imminent, personal, and proximate than non-EE students.

**Hypothesis 3 (H3).** Their prioritization will be different, especially for ERs whose evaluation requires deeper understanding of the causal relationships between various ecological phenomena.

2. Methods

2.1. Study Population, Site, and Sampling Procedure

The research students were recruited from two academic, environmental programs (i.e., environmental sciences and EE) and non-EE programs (i.e., exact sciences, social sciences, and the humanities) in two different academic institutions. On the basis of the formal published curricula and on the objectives of the programs on the institutional websites, the curricula of the environmental programs focused on subjects that reflect the current environmental crises in the world (e.g., climate change, loss of biodiversity, overconsumption of natural resources), the challenges and degradation of the natural world, its effect on the natural environment, as well as on human welfare and all other life on earth, and ways that humans can address these challenges as individuals and as members of the broader society in a sustainable way. The Israeli local context was included in the different courses to better engage the students in the subject and increase their awareness, care, and motivation to act to decrease local environmental degradation. The local context was included as part of the learners’ understanding of environmental challenges from a global and holistic perspective. The courses in the EE programs also addressed aspects of teaching and learning EE and provided learners with the relevant content pedagogical knowledge and skills required for an effective EE in formal and informal settings. Environment-oriented content was absent from the curricula of the non-EE programs that were investigated in this study.

Messages posted on bulletin boards invited students to join a short, 25–30 min survey in the computer classes in return for ILS 36 (USD $10). The survey topic was presented as “Thoughts and feelings towards environmental problems”. To receive the payment, candidates had to give their ID number, which enabled us to check whether they enrolled in a program that is environment-related or a program that is unrelated to the environment. The computerized questionnaire (Qualtrics) was programmed so that the order of the questions was randomly changed between respondents and that the next question did not appear until all the questions on the previous page were fully answered. This ensured there would be no missing data.
2.2. Ecological Risks Used In This Study

We looked for official and well-established sources of information that specified the ecological risks so that the problems presented to the respondents would reflect those that actually constitute the main problems in the country. We used a report entitled “The Quality of the Environment in Israel – 2010”, issued by the Ministry of Environmental Protection, which was written by dozens of the highest ranking environmental experts in Israel (State of the Environment in Israel: Indicators, Data and Trends 2010 [57]). According to this report, the 10 most severe problems in Israel were (not in order of importance): (1) soil pollution due to industrial waste, pesticides, fertilizers and oil leaks from gas stations; (2) industrial air pollution (factories, power plants, and industry); (3) transportation-related air pollution; (4) pollution of water sources and ground water by sewage, pesticides, and fuels; (5) pollution of the Mediterranean Sea; (6) the receding water level of the Dead Sea and formation of sinkholes; (7) loss of green areas for development and construction purposes; (8) loss of biodiversity; (9) disposal of waste and accumulation of garbage in public areas and in nature; and (10) long-term drought (consecutive years of decreased rainfall and water shortage. To this list we added three additional risks: (11) earthquakes—which represent a non-anthropogenic natural risk, and can therefore be expected to be perceived differently [25]. This risk was added to explore whether EE and/or non-EE students differentiate between anthropogenic environmental and non-anthropogenic pseudo-environmental problems; (12) fires—representing a natural risk and an actual issue at that time in Israel, when frequent outbreak of wildfires across the country had made headlines; and finally, (13) population growth and increasing population density—a main driver of the first 10 risks and an ethically sensitive issue in Israel, which has become the most densely populated country in the Western world [58]. Nevertheless, this issue is not mentioned in public discourse in Israel in general, nor in environmental discourse, in particular.

2.3. Development and Design of the Questionnaire

The questionnaire included closed questions (the quantitative part) and one open-ended question (the qualitative part). In the first part of the questionnaire, each of the 13 ecological problems was presented, in random order, along with the instruction “Please relate to the following problem”. Next, the following seven questions, referring to each of the risk attributes, were introduced: (1) In your opinion, to what degree does this problem pose a certain threat to humans and the environment? (2) In your opinion, does the problem directly affect the place where you live? (3) In your opinion, to what extent does the problem pose an immediate danger to humans and their natural environment? (4) In your opinion, to what extent do the negative effects of the problem pose a threat to you personally? (5) In your opinion, to what extent does the problem cause you to experience a negative emotion (such as sadness, anger, fear, or disgust)? (6) In your opinion, to what extent can the problem and its effect on humans and their natural environment be anticipated? (7) In your opinion, to what extent does the media report on the problem and its negative effects on humans and their natural environment? Finally, the eighth question, designed to assess the general severity ascribed to the ER, was posed: (8) In conclusion, to what extent do you see this problem as serious?

Each of the eight questions corresponded to a different dimension (or attribute) of the risk, and their inner order was randomly changed across the risks. Introducing the 8 questions, 13 times (for each ER) yielded 104 evaluations (13 ERs × 8 attributes) from each of the 232 respondents. Next, we asked the students to prioritize the problems according to their relative importance, where “1” symbolized the top of the list (most severe) and “13” the bottom of the list (least severe). In contrast to the previous section, in which the respondents could assign the highest level of severity to all of the ERs, in this case, they had to make an order of priority.

The previous prioritization question was then followed by the instruction: “Please explain why you chose the problem that was ranked as the most severe one.” This question was used later for the qualitative analysis.
The demographic part included questions relating to year of study, faculty of study, age, gender, and self-reported socioeconomic status (on a scale ranging from 1 = poor to 5 = excellent).

2.4. Quantitative Analyses

We employed a mixed-model design to test the differences between EE and non-EE students in (a) their ratings of perceived severity, (b) the perceived differences between the ERs (in a repeated-measures design), and (c) the weight given to each of the criteria (predictors) that determine perceived risk severity. Mean rankings were used to detect the differences between the two groups in the prioritization task. Finally, we used multidimensional scaling, which is an analytical technique designed to create graphical representations of the similarities and differences in the ratings of multiple objects (risks, in this case) [59,60]. This analysis is based on principal component analysis, which enables the identification of perceived relationships between various elements (risks) according to their spatial distance. Specifically, risks that are perceived as related are depicted closer to each other, in a cluster, whereas risks that stand alone represent risks that are perceived as unrelated.

2.5. Qualitative Analysis

The open-ended question relating to the reasons for the top-ranking risks was analyzed by an inductive content approach [61], which enables identifying emergent categories and major themes, focusing on the respondents’ reasons for ranking the most severe environmental problems. Validation was achieved by the following phases: We created an initial set of codes for the analysis of each question. Then, we met and discussed the codes, adding and changing some of them and confirming only the revised codes that we both agreed upon. Finally, we asked a third EE researcher to independently analyze the students’ written responses using our revised codes. Because the analysis of the third researcher was similar to our analysis, we confirmed the revised codes as the final ones.

3. Results

3.1. Demographic Data

Both academic institutions have different departments and programs for full-time as well as part-time students. A total of 232 students from various programs were recruited. A total of 103, who reported to have studied environmental science, life sciences, or geography programs, which usually include environmental topics in their curricula, were classified as EE students. The remaining 129 were recruited from other humanities and social studies departments, and were classified as non-EE students. The age ranged from 19–65 years in both groups, with means of 36.6 ± 10.50 and 30.1 ± 11.57, in the EE and non-EE groups, respectively. The mature age of the participants in our study stemmed not only from the fact that part-time students were included, but also because Israel is known to have the oldest student population in the world [62]. In the EE groups, 73 (70.8%) were women and 30 (29.1%) were men, and in the non-EE groups, 68 (52.7%) were women and 61 (47.3%) were men. The mean socioeconomic status of both groups was not significantly different, and was generally medium (3.37 ± 0.828 for EE students and 3.22 ± 0.847 for non-EE students, on a scale of 1–5).

3.2. Comparison Between EE and Non-EE Students

3.2.1. Perceived Severity of Environmental Problems

In general, the EE students perceived the mean severity of all the environmental problems as significantly more severe than the non-EE students, except for littering and earthquakes, in which no significant differences were found (see Figure 1), thus confirming H1. Only in the case of fires was the non-EE severity perception higher than that of the EE. The largest mean difference was found in the perception of population growth.
Figure 1. * designates statistically significant differences (independent samples t-tests, \( p < 0.05 \)); NS designates non-significant differences; EE: environmental education.

3.2.2. Perceived Risk Attributes

Table 1 shows that EE students perceived ERs as more certain, proximate, imminent, personal, and evoking stronger emotions compared to non-EE students, thus confirming H2. The only risk attribute that was not perceived significantly differently by the two groups was media coverage. The bottom row of Table 1 shows the perceived general severity, which was found to be significantly higher for EE students compared to non-EE students, as was previously shown in Figure 1.

Table 1. Comparison of perceived attributes of ecological risks (ERs) between EE versus non-EE students *.

| Perceived Attribute                  | Non-EE     | EE         | \( P \)** |
|-------------------------------------|------------|------------|----------|
| Certainty                           | 5.2 ± 0.95 | 5.7 ± 0.93 | <0.001   |
| Geographical proximity              | 4.6 ± 0.93 | 5.2 ± 0.95 | <0.001   |
| Imminence                           | 4.7 ± 0.95 | 5.3 ± 0.96 | <0.001   |
| Potential for personal harm         | 4.4 ± 0.96 | 5.0 ± 1.06 | <0.001   |
| Emotionality                        | 5.1 ± 1.06 | 5.7 ± 0.89 | <0.001   |
| Predictability                      | 5.0 ± 0.95 | 5.3 ± 0.77 | 0.015    |
| Media coverage                      | 3.2 ± 1.01 | 3.3 ± 1.08 | 0.175    |
| **Mean general severity**           | 5.5 ± 0.93 | 6.1 ± 0.62 | <0.001   |

* Means are mean evaluations of each attribute across all risk types, on a scale of 1 (low) to 7 (high).
** Independent samples t-test for one-sided hypotheses (H2, see text for details).

The differences between the two groups in mean severity and in mean evaluations of risk attributes are supported also by the mixed-model analyses, in which all of the risk types and the interactions between the risk types, the risk attributes, and the group were taken into account. Apart from showing that the two groups differ in severity evaluations, it showed three more important findings: (a) that the only significant predictors of perceived severity were the perceived certainty and the intensity of emotions aroused by the risks, (b) that mean evaluations of risk attributes significantly differed between the groups, and (c) the interaction between group \( \times \) risk attribute was not significant. In other words, the weight given to each of the risk attributes in the prediction of risk severity was similar for
both groups. Post-hoc tests allowed us to find the perceived resemblance between risk types that shows how similarly the risks were perceived by each group.

A graphical way to demonstrate the perceived resemblance between risks, together with their perceived attributes and the difference between the two groups is by multidimensional scaling of the risks and their attributes (Figure 2).

Figure 2. RepGrid spatial representation of the relationship between the ERs * on multi-dimensional axes representing perceived risk attributes. The bold line represents the general perceived severity.

*The numbers represent the following ERs: ① water pollution, ② industrial air pollution, ③ soil pollution, ④ transportation air pollution, ⑤ pollution of the Mediterranean Sea, ⑥ littering, ⑦ earthquakes, ⑧ fires, ⑨ drought, ⑩ loss of open space, ⑪ loss of biodiversity, ⑫ dehydration of the Dead Sea, ⑬ population growth.
This figure summarizes and simultaneously presents a lot of information that was obtained in the mixed-model analysis: First, it shows the relationship between the risk attributes. The insignificant difference in the group \( \times \) attribute interaction allowed us to depict the same attributes’ axes in the EE group (Figure 2A) as in the non-EE group (Figure 2B). Second, the axes’ spatial location revealed relationships between the risk attributes. For example, the almost overlapping axes of certainty and imminence shows that these two attributes were perceived similarly or as psychologically interchangeable. In addition, the proximity of the severity axis to the certainty and emotions axes shows, as was found by the mixed-model, how considerable the weight given to these two predictors of general severity was. Third, the spatial scattering of the risks shows that the risks in Figure 2A are less scattered than in Figure 2B, which means that they were perceived more similarly and are more interrelated in terms of their risk attributes. In addition, the whole risks’ scattering in Figure 2A is more concentrated on the right side of the figure, reflecting the confirmation of H2 that EE students perceived most risks as more imminent, certain, personal, and so on (see also Table 2). Focusing on specific risks, there were some interesting findings; for example, in the case of population growth, a dominant cause of most ERs, Figure 2A shows that population growth is located closer to the rest of the risks’ cluster, whereas in Figure 2B, it is located far away from all the other ERs. Another specific example is the difference in the locations of loss of biodiversity. This risk is located, in Figure 2A, much closer to the rest of the risks when compared with in Figure 2B, indicating a greater ecological awareness of the relationship between other risks (such as air, water, and soil pollution, as well as littering) and biodiversity loss.

### Table 2. Comparison of mean ranking of risk types for EE versus non-EE students. Higher priority is denoted by lower ranking.

| Ecological Risk                        | EE Rank | Non-EE Rank |  
|----------------------------------------|---------|--------------|
| Water pollution                        | 4.4 ± 2.71 \textsuperscript{a} | 1 | 4.3 ± 3.00 \textsuperscript{a} | 1 |
| Industrial air pollution               | 4.6 ± 2.89 \textsuperscript{a} | 2 | 6.0 ± 3.46 \textsuperscript{a} | 3–4 |
| Transportation air pollution           | 5.4 ± 2.73 \textsuperscript{a} | 3 | 6.0 ± 3.46 \textsuperscript{a} | 3–4 |
| Soil pollution                         | 5.5 ± 2.74 \textsuperscript{a} | 4 | 5.2 ± 2.78 \textsuperscript{a} | 2 |
| Pollution of the Mediterranean Sea     | 6.3 ± 2.98 \textsuperscript{a} | 5 | 6.3 ± 2.99 \textsuperscript{a} | 5 |
| Loss of biodiversity                   | 6.4 ± 3.44 \textsuperscript{a} | 6 | 7.5 ± 3.48 \textsuperscript{b} | 8 |
| Loss of open areas                     | 6.7 ± 3.28 \textsuperscript{a} | 7 | 7.7 ± 3.43 \textsuperscript{b} | 9 |
| Litter and littering                   | 7.2 ± 3.15 \textsuperscript{a} | 8 | 6.4 ± 3.32 \textsuperscript{a} | 6 |
| Population growth                      | 7.3 ± 4.48 \textsuperscript{a} | 9 | 9.8 ± 3.36 \textsuperscript{b} | 13 |
| Drought                                | 7.9 ± 3.66 \textsuperscript{a} | 10 | 7.2 ± 3.70 \textsuperscript{a} | 7 |
| Decline in Dead Sea water level        | 8.9 ± 2.99 \textsuperscript{a} | 11 | 9.0 ± 3.18 \textsuperscript{a} | 12 |
| Fires                                  | 9.6 ± 3.55 \textsuperscript{a} | 12 | 8.0 ± 3.83 \textsuperscript{b} | 10 |
| Earthquakes                            | 10.6 ± 3.74 \textsuperscript{a} | 13 | 8.9 ± 3.95 \textsuperscript{b} | 11 |

\* Different letters denote significant difference between mean rankings for \( \alpha = 0.05 \) two-sided tests.

#### 3.2.3. Prioritization of Environmental Problems

The order of the top five most important ecological problems was similar in both groups. However, loss of biodiversity and open areas were ranked significantly higher on the priority list of the EE group than that of the non-EE group. The largest difference in prioritization was in the case of population growth, to which EE students assigned a significantly higher priority than the non-EE students. The higher priority given by the EE students to population growth was found to be “at the expense” of the significantly lower priority given by them to fires and earthquakes. Our hypothesis concerning the different prioritizations (H3) was partly confirmed because, on the one hand, all five top ranking risks were similar in both groups but, on the other hand, the differences that were found do relate to ERs whose evaluation requires some ecological background.
3.2.4. Explanations of EE and Non-EE Students for Their Prioritization of the Ecological Problems

Our analysis of the students’ explanations for their choices of the most severe environmental risk yielded the following three major perspectives, with clear EE versus non-EE differences in their proportions:

(1) An anthropocentric perspective—adopted by two-thirds of non-EE students versus a quarter of EE students. This perspective emphasizes the direct impact of the problem on human quality of life in terms of the physical proximity or the geographical distance of the problem from the individual’s surroundings, focusing on the level of self-damage or damage to human life. In their responses, students addressed their own suffering from the problem or the suffering of humans in general, as illustrated in the following examples:

“I ranked the problems according to their prevalence and distance from my daily life ... Air pollution is the severest problem. We cannot live without clean air.” (non-EE student)

“Biodiversity is part of the food chain, [thus] loss of species would have a direct impact on humans.” (EE student)

“The thing that concerns me the most, as an ecologist, is harming the natural landscapes in Israel.” (EE student)

(2) A whole-system perspective—adopted by 10% of non-EE students versus 60% of EE students. This perspective emphasizes the impact of the problem on the whole ecological–social system in terms of the level of damage caused to non-human organisms, human responsibility to protect non-human organisms, the globalism of the problem, or its chain effect. The following examples demonstrate the whole-system perspective:

“Loss of open spaces will cause other problems, such as lack of place for waste. As a result, factories and individuals will pollute both the soil and the sea.” (non-EE student)

“Urban air pollution from factories and vehicles has a severe effect on human health and affects other organisms and biodiversity. It adds to the problem of global warming ... the damage has wide-ranging effects because the air moves and the pollution doesn’t stay in one place.” (EE student)

“Population growth in Israel is increasing because Israeli government policy brings about competition related to space between Jewish versus the Arab settlements. Encouraging birthrate on one hand and neglecting women’s education in marginalized areas on the other hand influence our needs to cope with expeditious building and development; it also pushes back other non-human species and makes it harder to cope with different types of pollution.” (EE student)

“Diverse organisms have their own right to live, but they are damaged by human activity. Meanwhile, we [humans] reap the benefit of the various ecological system services that we need to live.” (EE student)

The examples above reflect systems thinking by the students with respect to their understanding of the wide-ranging consequences of the problems for human as well as non-human creatures, their understanding of all organisms’ right to exist, or their understanding of the complex interrelations between the ecological, social, and political (demographic) aspects of population growth. This system thinking will be elaborated further on in the discussion.

(3) A solution-oriented perspective—adopted by 20% of non-EE and 20% of EE students. This perspective addresses the possibilities of solving the problem because solving it is relatively simple or accessible and human-dependent, or the impossibilities of solving the problem as a result of its complexity, inaccessibility, being a natural process and not human-dependent, or as a result of not being part of the national and public agenda. Despite the similarity in the percentage of students from both groups who adopted this perspective, some specific reasons were addressed differently by
the students, reflecting different levels of understanding of the nature of environmental problems. The EE students described in more detail different options for solutions and addressed the level of manageability, effectiveness, or the practicability of different solutions, reflecting the complex nature of environmental problems. In contrast, the non-EE students often offered more simplistic and one-dimensional explanations and did not specify clearly the characteristics of their different solutions. This is illustrated by the following quotes:

“Fires are natural. The hot, dry Israeli climate causes fires in the summer. It’s complicated to decide whether the fires are natural or are a result of climate change … sometimes fires even help the revival of natural forests.” (EE student)

“Addressing the problem of littering is manageable and could be solved by educating the public. This problem is human-dependent and not an act of nature, but requires us to make the effort to solve it.” (EE student)

“I think that now is the time to address sea pollution, as it is addressed much less than the problem of air pollution. Like air pollution, sea pollution has also a major impact on plants and animals.” (EE student)

“As the extinction of animals is a natural part of life, I’m not sure that the loss of biodiversity is caused purposely [by humans].” (non-EE student)

“I chose air pollution because humans are limited in fixing the damage caused by air pollution.” (non-EE student)

These examples reinforce the previous findings regarding the limited systemic understanding of environmental problems we found among the non-EE students.

4. Discussion

In this study, we examined the differences in environmental risk perception among diverse groups of students who differed from each other in that one group had not been exposed to any academic EE during their studies, whereas the other group had been exposed to EE, albeit at various levels. We found clear and significant differences in the perception of the overall severity of environmental problems, particularly in reference to the less “popular” and complex environmental problems that have extensive, global consequences. The reasons for the relative prioritization of different environmental conditions were also found to be different.

4.1. Perception of Overall Severity

Overall severity, in general, was perceived as higher by EE compared to non-EE students with regard to all of the ERs except three: littering, earthquakes, and fires. We begin by discussing the finding of the generally higher risk evaluations of EE compared to non-EE students, especially in the context of population growth. We continue with a discussion on the exceptional lack of difference in risk assessment for littering and earthquakes. We then conclude the discussion on the perception of overall severity with the finding that only in the case of fires was the non-EE severity assessment higher than that of the EE students.

Slimak and Dietz (2006) [2] compared the severity attributed to different risks among several groups of people with different risk literacy. They also found significant differences between the risk assessments of people with versus without an environmental background, and attributed them to differences in levels of concern and appraisal considerations for the various risks. Specifically, they noted that laypeople evaluated low-probability and high-consequence risks as more severe, whereas professionals assigned a higher priority to risks that are less familiar to the public but have a global influence, such as population growth. Our findings were similar to those of Slimak and Dietz in that
risks such as air, water, or soil pollution were assessed as immediate, close, personally relevant, certain, and highly severe by both populations. However, on the other hand, only EE students acknowledged the severity of the problem that is directly responsible for the development of these problems, namely, population growth. The visualization of the interrelation between the risks (presented in Figure 2) illustrates the psychological distance between the more familiar groups of risks (pollution types) and their generators. This may reflect the lay misperceptions about the current and proximal severity of the drivers and direct causes of most environmental problems [63] in contrast to the better understanding of systemic relationships that characterize the more environmentally literate. In particular, with regard to the impact of population growth, the recognition of the problem and the urgency of addressing it have been absent from the public agenda and repressed by the media [17,64–66]. It is no wonder then that the general public is not aware of the problem, its implications, and its severity.

Two risks were exceptional in that they were not perceived as more severe by the EE compared to the non-EE students: earthquakes and waste disposal. The lenient perception of both groups to earthquakes can be explained by the fact that this problem is considered less severe because of the low frequency of occurrence in Israel. In contrast, both groups similarly assigned relatively higher severity to the problem of waste disposal and accumulation. The relatively higher evaluation of severity and the lack of difference between the two groups may indicate that both groups saw it as a major nuisance, but further direct evidence is needed to confirm this suggestion.

Another risk which was not assessed as more severe by EE students was fires. In fact, this was the only risk in which non-EE students ascribed a significantly higher severity on average than EE students. To understand the reason for this, one should know that in Israel, fires are not considered among the main ecological problems, partially because there are no large forested areas. However, during the fall of 2016, the year in which the research was conducted, there was a wave of both wildfires and urban fires in Israel. Some occurred naturally and some were suspected to be the result of arson attacks. The salience of this issue in the public awareness may explain why this risk was perceived as highly severe. The phenomenon that local events that occur at the time of a study have a great impact on the evaluation of such events is not new; Spence et al. (2012) [67] also reported that exposure to local events (in their case, floods) increased the salience of these events and led to their over-estimation. This finding is consistent with a series of reports and studies on the impact of personal experience on belief in and evaluation of problems [56,68,69].

4.2. Perceptions of ER Attributes

In general, we found differences between the two groups, not only in evaluating the overall severity, but also in their perceived characteristics, such as immediacy, geographical proximity, personal relevance, and certainty. It is evident that compared to non-EE, EE students perceive anthropogenic environmental problems as more threatening in almost every possible aspect. A lack of environmental literacy is often characterized by a tendency to overestimate local relative to global phenomena [67,69]. Likewise, we found that non-EE students ranked most of the risks that have complex and extensive impacts, such as population growth, loss of biodiversity, and loss of open spaces, as having less personal relevance in the “here and now”. This finding can be related to the perception that problems that are time-delayed, abstract, and complex do not stimulate strong visceral reactions [69]. Given the great weight of emotional involvement in ER assessment, discussed next, it is clear why these risks were not highly valued by the non-EE students.

The finding that the only significant effects on severity assessment were the level of certainty and the negative feeling evoked by the risk is in line with theory-based expected findings, which relate to the decision-making process in an interaction between two different systems [1]. The first is an analytic system that “uses algorithms and normative rules, such as probability calculus, formal logic, and risk assessment” and the second is an experiential system which is “intuitive, fast, mostly automatic, and not very accessible to conscious awareness.” It relies on images and associations linked by experience to emotion and affect (a feeling that something is good or bad) [70]. Slovic et al.
further note that to properly manage risks, people need this parallel interplay between emotion and reason. We propose that the explanation for the finding that the only two predictors that had a significant effect on risk assessment were perceived certainty and emotional involvement may represent the two components identified by Weber (2006) [69] and Slovic et al. (2004) [70] as part of the psychometric paradigm. The perceived certainty represents the analytic system, and the intensity of negative emotions represents the affective, experiential system. Interestingly, the EE students perceived environmental risks as more certain and as evoking higher levels of negative emotions than the non-EE students, but the weight of certainty and emotions, as predictors of risk assessment, did not differ between the groups. This suggests that professional knowledge maybe insufficient to change the basic, two-system, decision-making mechanism. This explanation can be corroborated by Slimak and Dietz’s (2006) [2] study, which noted that these two systems exist both in experts and in non-risk specialists.

4.3. Contribution of EE to ER Perception

Our findings clearly show that those with an environmental background assessed the environmental risks as more severe and rated all aspects of the risks’ implications as more certain, spatially and temporally close, and personally relevant. In addition, compared to the non-EE students, the EE students perceived with greater severity the impact of the less familiar and less “popular” risks, whose effects are more complex and less visible. There may be at least two possible explanations for this finding. The first is that what created the difference was the exposure to EE, which provided tools that improved the ability to assess the potential and widespread impacts of environmental problems, along with skills to understand the connection between various environmental problems, including those that are more abstract and less spoken about in the media. This is supported by Slovic (1997) [71] and Zhang et al. (2013) [56], who found that EE contributed to elicitation of change in various variables related to risk perception. The second explanation is that these differences in perception may have existed in the first place and this motivated some people to enroll in environmental programs or take a course in this subject; thus, it was not really the learning process that made the difference. This is supported by Alkaher and Goldman, (2017) [72], who found that people who choose to study in environmental academic programs have high levels of environmental awareness and personal interest in protecting the environment prior to their studies, which motivates them to enroll in environmental studies. The two explanations may not be mutually exclusive. Because only a pre-post research design can provide an unequivocal answer, we suggest that it is reasonable to assume that at least some of the findings can be attributed to the acquisition of tools and skills during the course of studies, as most of them are not common knowledge. Support for this suggestion consists of studies using a pre–post design, showing that exposure to an environmental academic education indeed increases positive environmental attitudes and environmental knowledge, particularly in those areas that require more complex understanding, resource management, policy prioritization, and informed decision-making [6,54,73–75]. The aforementioned changes are, in fact, the skills and tools that enable one to assess environmental risks and the connection between various environmental problems. In addition, one of the most important elements of life science education, especially EE, is the development of systems thinking, a cognitive ability that can be developed through instructional learning [76–78]. We therefore suggest that it is reasonable to assume that the improved skills acquired during EE contributed, to one degree or another, to the difference pattern found in this study. The conclusion that, compared to non-EE students, EE students have, on average, better systems thinking and an enhanced ability to understand the connectivity between the various problems, is supported by the quantitative as well as the qualitative findings.

This difference is clearly demonstrated in the students’ perspectives concerning their prioritizations of the most severe risk. The tendency of the non-EE students to view environmental risks mainly through anthropocentric lenses and not through systemic lenses, as well as their tendency to give one-dimensional responses regarding the possibilities or impossibilities to address such risks, probably reflects the non-EE students’ low level of environmental awareness and caring. This difference
in students’ views could also limit the ability of the non-EE students to consider man–nature interrelationships as they make decisions concerning environmental issues. This suggests that EE broadens peoples’ perceptions and understanding regarding the nature and consequences of environmental problems, and contributes to their ability to view these problems through holistic and multi-dimensional lenses. In addition, it is reasonable to assume that heightened risk perception will be translated to action, as Carmi and Kimhi (2015) found among students that higher risk perception resulted in a stronger willingness to act and make sacrifices for the sake of the environment, and Carmi and Bartal (2014) [79] reported that students who perceived environmental threats as more severe reported a higher engagement in environmental behavior. In general, risk perception is considered one of the essential prerequisites for action. Gifford (2011) [80] named perceived risk as one of the seven “dragons of inaction”, meaning that risk perception constitutes a psychological barrier that limits climate change mitigation and adaptation. Similarly, Lacroix and Gifford (2018) [81] found that heightened climate change risk perception was associated with fewer perceived barriers to engagement in energy conservation behavior and more reported energy conservation behaviors.

On the basis of our findings, we have several recommendations for an effective inclusion of ER education in higher education institutions in both EE and non-EE academic programs. Overall, we suggest that instructors adopt Schenk et al.’s (2019) [46] model of risk in their teaching when analyzing risks. This model was found to be a useful framework in science education practice, as it offers a set of elements that may be introduced to learners in different ways for different purposes, and it suggests various relationships between those elements which are not intuitive and not always explicit. It is based on the idea that the concept of risk is multidimensional. The elements of uncertainty, probability, severity, and consequence are at the center of the risk concept, and activity, knowledge, and values elements are framed around them. This model also corresponds to the perception that risk assessment and prioritization expresses, to a certain extent, a sociocultural construction [16]; thus, education for risk literacy should also take these variables into account. Using this model to improve students’ risk literacy, as part of improving their scientific literacy, offers the following new insights for learners—it juxtaposes probability and severity, both subject to uncertainty and both modifying the consequences of risks; it connects between risk and decision-making, which in turn could encourage students to manage or mitigate risks in their own lives. In addition, it highlights the interaction of values (subjective matter) and knowledge (objective facts) in activities involving risk, enhancing students’ understanding that reducing risks is complex—values and knowledge are not always equally represented in a risk issue, and the activities to reduce a risk involve both subjectivity and objectivity to varying degrees. These new insights could improve the systems thinking (that was found to be lower among the non-EE students in this study) of EE, as well as non-EE students regarding ERs, and help them perceive and assess risks better. For this reason, we suggest that instructors from academic programs outside the field of science education use this model, too, in their practice.

We also believe that it would be beneficial if higher education instructors themselves were better acquainted with the psychometric paradigm [1] to better understand the mechanisms of their own as well as their students’ understanding of the perceived risks of various environmental issues. This understanding is needed as the first step towards improving students’ risk literacy.

Finally, we claim that including ER-related issues in academic courses both in EE and non-EE programs provides a good opportunity for higher education institutions to better understand and assess ERs and act towards mitigating them. In a world of environmental crisis, which is intensifying economic and social issues, society looks to institutions of higher education to create, develop, and apply the knowledge and the tools required for tackling these complex challenges.

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