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Understanding Attitudes and Awareness of Renewable Energy Sources and Implications for Sustainability Education among Minority Arab Communities

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ABSTRACT

Purpose This study examines the awareness and attitudes regarding renewable energy among 360 Arab students and 180 teachers across elementary, middle, and high schools in northern Israel. Using a quantitative cross-sectional survey design, data was collected via structured questionnaires focusing on knowledge of solar, wind, and hydroelectric energy sources and attitudes towards their use. **Methodology** The methodology included descriptive statistics and inferential analyses, such as Pearson correlations and multivariate analysis of variance (MANOVA), to compare differences across educational levels and between students and teachers. **Results:** High school students reported higher awareness (M = 3.36 on a 5-point scale) than middle school (M = 2.53) and elementary school students (M = 1.91), and teachers reported the highest awareness (M = 3.95). Attitude scores followed the same increasing trend by educational level. A significant MANOVA indicated group differences in awareness and attitudes across teachers and students in Grade 6, Grade 9, and Grade 12 ($p < .001$). Post hoc tests confirmed that each successive educational level showed higher mean awareness and more favorable attitudes than the preceding level. Awareness was strongly correlated with attitudes among students ($r = .72$, $p < .001$) and more modestly correlated among teachers ($r = .27$, $p = .004$). In addition, 85% of teachers supported incorporating renewable energy into the school curriculum, and 52% reported needing further training to teach these topics. **Implications for research and practice:** The findings highlight moderate overall levels of knowledge and positive sentiment toward renewables, with clear gains in both as education level rises. These results underscore the pivotal role of education in fostering environmental awareness and shaping attitudes toward sustainability. The study provides practical insights for integrating sustainability education in minority communities, particularly the importance of teacher training and age-appropriate curriculum, thereby aiding efforts to promote renewable energy adoption in culturally diverse contexts.

Introduction

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Climate change and environmental degradation have intensified the global push towards renewable energy, highlighting the need for broad public understanding and support of sustainable energy solutions. Achieving climate and sustainability goals is not only a technological or economic challenge but also a social one, wherein public attitudes and awareness play a crucial role. Education has been identified as a key driver in shaping these attitudes and improving awareness of renewable energy, ultimately influencing the adoption of green technologies (Iqbal et al., 2023; Li et al., 2023; Ucisik Erbilen, 2013).

Recent studies across various countries provide strong evidence that higher levels of education in a population are associated with increased renewable energy uptake and lower environmental impacts. For instance, analyses of G-20 and BRICS nations show that improvements in educational attainment correlate with greater use of renewables and reductions in carbon emissions. Likewise, country-specific research in major economies such as China and Japan demonstrates that investments in education—especially in environmental and technical fields—significantly increase renewable energy innovation and consumption, aiding carbon-reduction efforts (Partini & Ekananda, 2023). Taken together, this literature suggests that educational attainment is consistently associated with stronger renewable energy uptake and related sustainability indicators (Lu et al., 2022; Partini & Ekananda, 2023)

At the individual level, knowledge and awareness are closely intertwined with attitudes towards renewable energy and pro-environmental behavior. The widely recognized Knowledge–Attitude–Behavior model of environmental education posits that increasing knowledge can foster more positive attitudes, which in turn may lead to supportive actions. Research indeed indicates that informed individuals are more likely to support and adopt renewable technologies, as knowledge helps build trust in and appreciation for these alternatives (Qamruzzaman et al., 2023). For example, surveys in Europe show that those with greater factual knowledge about renewables have more favorable attitudes toward using such energy sources in daily life (e.g., being willing to install solar panels or supporting wind projects).

In developing countries, similar patterns emerging higher education levels have been linked to greater awareness of climate change and a willingness to engage in sustainable practices (such as conserving energy or accepting renewable energy policies). Conversely, a lack of awareness can be a barrier to renewable energy adoption, as people may hold misconceptions or low interest in technologies they do not understand. These insights suggest a virtuous cycle in which education fosters knowledge, knowledge cultivates positive attitudes, and those attitudes can ultimately motivate pro-environmental behaviors, such as supporting renewable energy projects or making personal investments in clean energy (Zhou et al., 2023).

Despite global recognition of the importance of sustainability education, it is not always clear how well current educational systems are imparting knowledge about renewable energy or shaping student attitudes on this topic. It is therefore valuable to examine the state of awareness and attitudes among school-aged populations, particularly in communities where renewable energy education may not be a formal part of the curriculum. Understanding the baseline knowledge and perceptions can identify gaps and guide future educational interventions. This study focuses on the Arab minority

community in Israel, a group for whom sustainability education—and science education in general—operates within a unique sociocultural and linguistic context. The following section synthesizes research on renewable energy education and clarifies the relevance of examining Arab students and teachers in Israel.

Literature Review

Renewable Energy Education Efforts and Awareness Levels

Around the world, educators are experimenting with innovative strategies to integrate renewable energy concepts into teaching, reflecting a growing consensus that sustainability topics should be introduced early and often in schooling. Project-based learning has been successfully employed to increase student engagement with renewable energy engineering concepts; for instance, Ariza and Olatunde-Aiyedun (2023) describe a case where high school students developed an electric vehicle as a hands-on project, which not only taught engineering skills but also improved students' understanding of sustainable transportation.

Similarly, game-based learning platforms like Minecraft have been adapted to teach young students about sustainable development goals, including renewable energy scenarios, in a playful yet informative way (Kersánszki et al., 2023). Alongside these, digital and mobile learning tools have emerged to broaden access to renewable energy education. In developing countries, where schools may lack laboratory resources, mobile applications and low-cost remote labs allow students to virtually experiment with solar or wind energy setups (Hoque et al., 2023; Yordanov et al., 2023). These pedagogical innovations indicate a widespread effort to boost renewable energy literacy.

However, despite such efforts, recent empirical studies suggest that current levels of awareness and understanding of renewable energy among students are often only moderate. For instance, a survey of vocational high school students in Indonesia found that their average awareness of renewable energy concepts was only about **57%** on a knowledge scale, which the authors classified as a "moderate" level of awareness (Agung Pambudi et al., 2024). Even university students in technical fields demonstrated far from complete knowledge (around 75% on the same scale).

Shehzad et al. (2023) similarly argue that the inclusion of "renewable energy education" in school curricula is not yet widespread; many students graduate with only a cursory understanding of topics like solar or wind power. This gap in formal education can translate into lukewarm attitudes: students might have heard of renewable energy in passing but lack a deep understanding of its importance, leading to ambivalence or only mild support for renewable initiatives (Shehzad et al., 2023). In some cases, limited knowledge fosters misconceptions.

A Hungarian study by Szakály et al. (2020) revealed that while the vast majority of surveyed individuals had heard of solar energy, there were persistent misunderstandings about less familiar sources (e.g., bioenergy) and about the capabilities of technologies like solar panels. Misconceptions of this sort can temper enthusiasm and illustrate why mere awareness of the term "renewable energy" is not the same as having an informed, positive attitude toward it.

Role of Teachers and Sociocultural Context

Teachers are pivotal in the educational ecosystem, especially for emerging topics like renewable energy. Their own awareness and attitudes toward renewable energy significantly influence whether and how these topics are taught in classrooms. A well-informed teacher who values sustainability is likely to incorporate examples of solar, wind, or other renewable technologies into lessons and to convey their importance with enthusiasm. On the other hand, if teachers themselves lack knowledge or interest, they may gloss over or entirely omit renewable energy content, even if it appears in the curriculum (Hoque et al., 2023).

Recognizing this, some educational programs have begun focusing on teacher training for renewable and environmental education. In the United Arab Emirates, for example, AlKaaki et al. (2032) describe initiatives where teachers undergo workshops on renewable energy technologies to ensure they have up-to-date content knowledge and pedagogical techniques for sustainability topics. Studies have found that teachers who receive such training feel more confident and motivated to engage students in sustainability projects (Hoque et al., 2023). These findings suggest that gains in students' renewable energy awareness are likely to depend partly on strengthening teachers' content knowledge and instructional confidence.

Beyond the school walls, the broader sociocultural context can mediate how renewable energy education is received. Community values, economic priorities, and minority status can all shape educational experiences. In the Middle East, there is growing policy-level acknowledgment of sustainability education, but practical implementation in schools has been uneven (Hoque et al., 2023). Within Israel, Arab students typically attend Arabic-language schools that operate under the state education system but face distinct challenges. Historically, these schools have had fewer resources and less emphasis on advanced scientific and environmental topics compared to the Jewish Hebrew-language school sector (Dallasheh & Zubeidat, 2023; Marsel et al., 2022).

The Arab community's educational agenda has often centered on improving core subject achievement and closing gaps in higher education access, potentially leaving sustainability topics as a lower priority. Additionally, language may be a barrier: most scientific materials and environmental curricula in Israel are developed in Hebrew, and relatively fewer resources are available in Arabic. Arab teachers and students navigate a multilingual reality—Arabic at home and school, Hebrew in official and public domains, and English in scientific literature (Ganayim, 2023)—which could make it more difficult to integrate new content like renewable energy, especially if quality Arabic-language educational materials are lacking.

Cultural factors might also influence attitudes; for example, communities that are less exposed to national environmental campaigns or that have immediate economic concerns might view renewable energy as a luxury issue, not a priority. While some grassroots initiatives have attempted to promote environmental learning in Arab communities (such as joint Jewish–Arab sustainability projects or eco-education programs in specific villages; see (Hansen, 2023)), it remains unclear how much impact these have on the typical Arab student's awareness and attitudes. In sum, the context of Arab schools in Israel presents a

unique and underexplored case where minority status, language, and education policy intersect in shaping sustainability education.

Research Gaps, Research Questions and Hypotheses

Despite expanding international research on renewable energy awareness and attitudes in educational settings, evidence focused on Arabic-language school contexts in Israel remains limited, particularly studies that examine students and teachers within the same design. Prior work provides useful benchmarks for typical awareness levels and misconceptions in different countries and age groups (e.g., (Agung Pambudi et al., 2024; Szakály et al., 2020)), but does not address how renewable energy awareness and attitudes vary across schooling stages in Arab schools in northern Israel, or how strongly awareness and attitudes are linked within students versus teachers.

By comparing Grade 6, Grade 9, Grade 12 students and teachers in one survey framework, the present study provides baseline estimates that can inform curriculum planning and teacher development efforts that are tailored to minority-language educational settings. The present study was designed with three primary objectives: (1) to assess the current levels of awareness and attitudes toward renewable energy sources among Arab students and teachers; (2) to compare these levels between teachers and students at different grade levels, thereby examining how education and age relate to awareness and attitudes; and (3) to evaluate the relationship between awareness and attitudes within each group (students and teachers), testing whether greater knowledge is associated with more positive attitudes.

The following specific research questions and hypotheses guided the study:

RQ1: *What are the levels of awareness and attitudes regarding renewable energy sources among Arab students and teachers?*

H1: *Overall, students' and teachers' awareness and attitudes regarding renewable energy sources will be moderate at best. Based on prior findings of moderate knowledge in various student populations, we expect that on the 1–5 scales used, the mean scores for both awareness and attitude will hover around the mid-point (indicative of moderate familiarity and moderately positive attitudes, rather than very high or very low).*

RQ2: *What differences exist in awareness and attitudes toward renewable energy between groups at different educational levels (elementary students, middle school students, high school students) and between students and teachers?*

H2: *There will be significant differences in the levels of awareness and attitudes among the groups, such that higher education level corresponds to higher awareness and more positive attitudes. In particular, we anticipate that teachers will have the highest awareness and most positive attitudes, followed by high school students, then middle school students, and that the lowest values will be observed in elementary students. This hypothesis is in line with the expectation that knowledge accumulates with age/education and that attitudes become more favorable as understanding grows.*

RQ3: *Is there a relationship between the level of awareness and the attitude toward renewable energy within the student group and within the teacher group?*

H3: *There will be a positive correlation between awareness and attitude levels in both groups. We expect that individuals who know more about renewable energy will also exhibit more positive attitudes towards it. Furthermore, based on the idea that younger individuals' opinions might be more directly shaped by their recent knowledge acquisition, we explore whether this correlation is stronger among students than among teachers (older adults may have more fixed attitudes less dependent on current knowledge).*

Methodology

Research Design

This study employed a quantitative, comparative-correlational survey design. The research was cross-sectional in nature, gathering data from multiple groups at a single point in time. We used structured questionnaires to measure two key dependent variables: (1) awareness of renewable energy sources, and (2) attitudes towards renewable energy. The design is comparative in that it examines differences across groups (teachers vs. students at three grade levels) and correlational in that it assesses the relationship between awareness and attitude scores. The overall approach is non-experimental and descriptive, aiming to characterize the current state of knowledge and opinions without manipulating any variables.

Participants and Sampling

The target population consisted of Arab teachers and students in elementary, middle, and high schools in the northern region of Israel. From this population, we obtained a convenience sample of 540 respondents. This sample included 180 teachers and 360 students, reflecting an effort to have balanced representation of educators and learners. The student subsample (N = 360) was evenly divided across three grade levels, Grade 6 (n = 120), Grade 9 (n = 120), and Grade 12 (n = 120). These grades were chosen as representative of upper elementary, middle, and high school levels, respectively.

The teacher subsample (N = 180) was also stratified by the level of school in which they taught: 60 teachers from elementary schools, 60 from middle schools, and 60 from high schools. Within the student group, there was a roughly equal gender split (54.4% boys, 45.6% girls), and ages ranged from 11 to 18 years (Mean age = 14.45, SD = 2.47). The teacher group (of whom 36.1% were men and 63.9% women) ranged in age from 27 to 56 years (Mean age = 41.5, SD = 8.9).

Teaching experience among the teachers varied widely, ranging from 1 to 34 years (M = 17.7, SD = 8.9). In terms of education, 48.9% of the teachers held a bachelor's degree, 46.1% held a master's degree, and 5% had a doctoral degree. A large majority of the teachers were married (85%), with 10% single and 5% separated/divorced or widowed. We also asked teachers to self-report their perceived economic status: approximately 29% described their economic status as below average relative to Israeli standards, 35.6% as around average, and 35.6% as above average. Because recruitment relied on school access and voluntary participation, the sample is best characterized as convenience-based; nonetheless, respondents were drawn from multiple schools and levels to capture variation within the target population.

Instruments

Data was collected via a self-report questionnaire comprising three parts: (1) a demographic section, (2) an awareness scale for renewable energy, and (3) an attitudes scale toward renewable energy. The questionnaires were developed in Arabic (the participants' native language) to ensure clarity and were administered in a paperless format (online).

1. **Demographic Information:** Participants answered basic questions about themselves. Students reported their grade level, age, and gender. Teachers provided their age, gender, years of teaching experience, highest educational qualification, marital status, and a subjective assessment of economic status. These questions were included to characterize the sample and to allow for potential post-hoc analyses of whether demographics relate to awareness or attitudes (though such analyses are beyond the main scope of this study).
2. **Renewable Energy Awareness Scale:** We measured awareness of renewable energy sources using a custom set of 10 items. Each item asked about a specific type or aspect of renewable energy (e.g., solar energy, wind energy, hydropower, biomass, geothermal energy, etc.), and respondents indicated their familiarity on a 5-point Likert-type scale. The scale ranged from 1 ("I have never heard of this energy source") to 5 ("I know this energy source very well"). These items were adapted from established surveys and prior research that assessed public knowledge of energy technologies.

In particular, we drew inspiration from a U.K. government public attitudes questionnaire (Department for Business. Energy & Industrial Strategy, 2020) which uses the phrasing "never heard of it" for knowledge of various energy sources, and from a recent Turkish study that measured farmers' awareness of renewables with a similar 5-point format (Yener Ögür, 2024). By averaging the 10 item scores, we computed an overall awareness score for each participant (possible range 1–5). A higher mean indicates greater overall awareness of renewable energy concepts. Internal consistency for the 10-item awareness scale was high in the current sample (Cronbach's $\alpha = .86$).

Evidence supporting content validity was based on item development informed by prior public attitudes instruments and relevant empirical studies, along with review by bilingual experts for clarity and appropriateness for the target age groups. Scores were computed as the mean of the 10 items (range 1 to 5), with higher values indicating greater self-reported awareness of renewable energy sources.

3. **Renewable Energy Attitude Scale:** To gauge attitudes, we developed 10 statements reflecting opinions or evaluative stances toward renewable energy, relative to traditional energy sources. Respondents rated their agreement with each statement on a 5-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). Sample attitude items included sentiments like "Investing in renewable energy is important for our future," "I support installing solar panels or wind turbines in my community," and reverse-coded statements such as "Conventional energy sources like oil and gas are more reliable than renewable sources" (disagreement with the latter indicates a pro-renewable attitude).

The attitude items were informed by questionnaires used in national energy attitude surveys (e.g., (Department for Business. Energy & Industrial Strategy, 2020)) and by academic studies that examined public acceptance of renewable energy projects. After reversing negative items, we calculated each individual's attitude score as the average of the 10 responses, so that higher scores represent more positive attitudes towards renewable energy. The attitude scale showed good internal consistency in the current sample (Cronbach's α = .83). The item set was designed to reflect multiple facets of attitudes toward renewable energy, including perceived benefits, affective evaluations, and behavioral intentions, and was reviewed by bilingual experts to support clarity and content coverage.

Both the awareness and attitude sections were reviewed by two independent experts (bilingual in Arabic and experienced in energy or environmental education research) to ensure that the language was clear and appropriate for the target age groups. Minor wording adjustments were made based on their feedback to improve clarity. We also pilot-tested the questionnaire with a small group (10 students and 5 teachers not in the final sample) to ensure that the online format worked smoothly and that the questions were understood as intended.

Data Collection Procedure

Data collection was carried out in accordance with ethical standards for research with human participants. Prior to distributing the survey, we obtained necessary permissions from school principals and informed consent from all participants (and from parents for underage students). The survey was hosted on the Google Forms platform and distributed via a combination of email and social media channels. For the student participants, invitations to participate in the survey were sent through their schools and teachers. Parents of student participants received an information sheet about the study and were asked to provide consent for their child's participation.

To encourage honest responses, we emphasized anonymity and confidentiality: respondents were instructed not to enter any identifying information like names or ID numbers on the survey form. The online form was set up so that email addresses were not collected, ensuring responses could not be traced back to individuals. We also highlighted that participation was voluntary and that one could quit the survey at any point before submission without any penalty.

Additional steps were taken to ensure that younger participants could complete the survey comfortably. For Grade 6 students, completion occurred in a quiet setting with the option to ask for clarification on instructions if needed; participants were reminded that there were no right or wrong answers and that responses should reflect their own views. Typical completion time was approximately 10 to 15 minutes for students and 15 to 20 minutes for teachers.

After the target sample size (which we set at a minimum of 500 total responses) was reached, we closed the survey link. The data from Google Forms were then downloaded into a spreadsheet format. To prepare for analysis, each response was checked for completeness; a small number of cases where more than 20% of the questions were unanswered were removed from the dataset (this accounted for the slight oversampling

beyond 540, as we ended with exactly 540 usable responses). We assigned a numeric ID to each response and removed any fields that could function as indirect identifiers in the working dataset. The online form did not collect names or email addresses, and responses were analyzed in anonymized form.

Data Analysis

Our analysis proceeded in several steps corresponding to the research questions and hypotheses:

1. Descriptive Statistics: We first examined basic descriptive indicators for all key variables. This included calculating mean and standard deviation for the awareness score and the attitude score within each subgroup (6th graders, 9th graders, 12th graders, and teachers). We also checked the distributions of these scores for any obvious skew or anomalies. Demographic characteristics were summarized as well, though these were not the primary focus of our hypotheses.
2. Group Comparisons (MANOVA/ANOVA): To address RQ2 and test H2 (differences between groups), we employed a multivariate analysis of variance (MANOVA). The MANOVA was set up with the participant group (four levels: Grade 6 students, Grade 9 students, Grade 9 students, and teachers) as the independent variable, and the two variables (awareness and attitude) as the multiple dependent outcomes. This approach allowed us to test group differences on both outcomes simultaneously, controlling the correlation between awareness and attitude. A statistically significant MANOVA result would indicate that, overall, the profile of scores differs by group. Following the MANOVA, we planned separate one-way ANOVAs for each outcome to see the group effect on awareness and on attitude individually. Given a significant F-test in ANOVA, we conducted post-hoc pairwise comparisons between groups using the Tukey HSD procedure (which is appropriate for equal sample sizes and controls the Type I error rate) to pinpoint which specific group differences were significant. Our primary interest was in the hypothesized trend by education level (i.e., 6th < 9th < 12th < teachers). Effect sizes (Eta squared or Cohen's *d* for pairwise differences) were calculated to assess the magnitude of differences.
3. Correlation Analysis: To address RQ3 and test H3 (relationship between awareness and attitude), we computed Pearson's correlation coefficient (*r*) between the awareness score and the attitude score for the student group and for the teacher group separately. We chose to examine these groups independently because H3 included the possibility that the strength of the relationship might differ by group. A Fisher *z*-test was later used to compare the two correlation coefficients to see if the student *r* was significantly different from the teacher *r*. In interpreting the correlations, we followed common guidelines (e.g., $r \sim 0.1$ as small, ~0.3 as moderate, ~0.5 or above as large), but the substantive meaning was more important: a positive and significant *r* would support the hypothesis that greater awareness is associated with more positive attitudes, whereas a near-zero or negative *r* would suggest little to no such association.

Throughout all analyses, we used a two-tailed significance level of \alpha = .05. For key results, we report exact p values where relevant and use conventional thresholds (e.g., $p < .05$, $p < .001$) when exact values are not informative. Awareness and attitude scores were computed as the mean of their respective items and analyzed as continuous outcomes

in the MANOVA, ANOVAs, and Pearson correlations. Prior to inferential testing, we screened the composite score distributions and evaluated homogeneity of variance using Levene's test. Effect sizes are reported alongside inferential statistics to support interpretation of practical significance

Results

A total of 540 questionnaires were analyzed (180 teachers and 360 students evenly split across 6th, 9th, 12th grades). There were no missing values for the key outcome variables (awareness and attitude), because the online form required responses to all Likert-scale items; a small number of cases were excluded earlier due to missing demographic information or incomplete survey submission. In what follows, we first present descriptive results addressing RQ1 (overall levels of awareness and attitudes), followed by the comparative results for RQ2 (group differences), and finally the correlational findings for RQ3 (relationships between awareness and attitudes within groups).

Descriptive Findings (RQ1)

The overall levels of awareness and attitudes were gauged by looking at mean scores on the 1–5 scales for each group. Across the total sample, the mean awareness score was 3.05 (SD = 0.92) and the mean attitude score was 3.09 (SD = 0.84). These values are close to, and slightly above, the scale midpoint of 3, indicating moderate awareness and moderately positive attitudes overall. However, as expected, these levels varied considerably by subgroup. The data in Table 1 show a clear increasing trend in both awareness and attitudes from younger students to teachers.

Table 1

Mean Awareness and Attitude Scores (with Standard Deviations) by Participant Group

Participant group	n	Awareness, M (SD)	Attitude, M (SD)
Grade 6 students	120	1.91 (0.40)	2.21 (0.47)
Grade 9 students	120	2.53 (0.49)	2.59 (0.52)
Grade 12 students	120	3.36 (0.45)	3.27 (0.53)
Teachers	180	3.95 (0.49)	3.90 (0.51)
Total sample	540	3.05 (0.92)	3.09 (0.84)

Note. Scores are on 1–5 Likert-type scales. Higher scores indicate greater renewable energy awareness or more positive attitudes toward renewable energy.

As Table 1 illustrates, Grade 6 students had the lowest mean awareness (M = 1.91, SD = 0.40), indicating that on average they were between "never heard of" and "have heard of but not knowledgeable" regarding common renewable energy sources. Their attitude mean was 2.21 (SD = 0.47), which suggests mildly positive attitudes (just above "neutral" agreement with pro-renewable statements). Grade 9 students reported higher awareness (M = 2.53, SD = 0.49) and attitudes (M = 2.59, SD = 0.52) than sixth graders, though these were still in the moderate range. Grade 12 students showed a further increase, with mean awareness 3.36 (SD = 0.45) and attitude 3.27 (SD = 0.53).

Notably, the 12th graders' awareness mean above 3 implies that many of them claimed to know renewable sources "well" rather than just having heard of them. Their attitude

above 3 indicates a generally positive leaning in views about renewable energy. Teachers had the highest scores on both measures: mean awareness was 3.95 (SD = 0.49), approaching the "know very well" end of the spectrum for most items, and mean attitude was 3.90 (SD = 0.51), indicating that teachers on average "agree" with favorable statements about renewables (for example, many teachers strongly supported renewable energy development and use). The standard deviations were roughly similar across groups (about 0.4 to 0.5), suggesting comparable variability within each group. These descriptive patterns are consistent with H1, with student scores clustering around the midpoint and teacher scores higher but still below the upper end of the scale.

Group Differences in Awareness and Attitudes (RQ2)

To rigorously test **H2** (that there are differences between the groups corresponding to education level), we performed a one-way MANOVA with group as the factor (four levels: 6th, 9th, 12th, teacher) and the two dependent variables of awareness and attitude. The MANOVA revealed a significant multivariate effect of group, Wilks' $\Lambda = .17$, $F(6, 1068) = 96.05$, $p < .001$. This indicates that considering the two outcomes together, at least one of the groups differs from the others. We proceeded to examine the results for each outcome separately via ANOVAs.

For awareness, a one-way ANOVA showed a highly significant difference among the four groups, $F(3, 536) = 335.07$, $p < .001$. For attitude, the ANOVA also found a significant group effect, $F(3, 536) = 208.11$, $p < .001$. These results confirm that both awareness and attitude depend on group membership (i.e., whether the respondent is a young student, older student, or teacher). The group effect was large for awareness ($\eta p^2 = .65$) and substantial for attitudes ($\eta p^2 = .54$), indicating that a sizable proportion of variance in scores was associated with participant group.

To understand the pattern of differences, we conducted post-hoc Tukey comparisons for all pairwise group contrasts on each variable. The key significant differences are summarized below (all at $p < .001$ unless noted otherwise):

- **Awareness:** Sixth graders scored significantly lower than ninth graders ($\Delta M = 0.62$, 95% CI [0.47, 0.77]). Ninth graders, in turn, scored significantly lower than twelfth graders ($\Delta M = 0.83$ [0.68, 0.98]). Twelfth graders scored lower than teachers ($\Delta M = 0.59$ [0.45, 0.73]). In fact, every pairwise comparison among different educational levels was significant for awareness, reflecting a monotonic increase: 6th < 9th < 12th < teachers. No two adjacent groups had overlapping confidence intervals for their means.
- **Attitudes:** A parallel pattern was observed. Sixth graders had significantly less positive attitudes than ninth graders (Mean diff = 0.38 [0.21, 0.55]). Ninth graders were lower than twelfth graders (Mean diff = 0.68 [0.51, 0.85]). Twelfth graders were lower than teachers (Mean diff = 0.63 [0.47, 0.79]). Again, all these differences were statistically significant. Thus, attitudes became progressively more favorable with higher grade levels and were most positive among teachers. All pairwise Tukey HSD comparisons were significant for attitudes (all ps < .001), indicating that each successive educational level showed higher mean attitude than the preceding level, and that teachers differed significantly from each student grade.

These findings strongly support **H2**. They confirm that teachers and older students have markedly higher awareness of renewable energy than younger students, and similarly more positive attitudes. For clarity, the group means are visualized in Figure 1, which provides a graphical depiction of the trends:

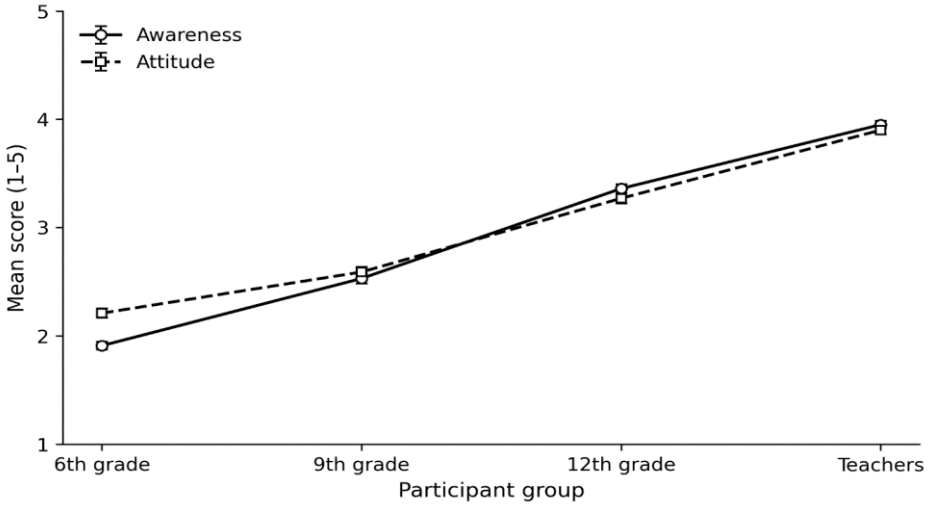

Figure 1: *Mean awareness and attitude scores by group (Grade 6, Grade 9, Grade 12 students, and teachers)*

As shown in Figure 1, the increase from one educational stage to the next is not only statistically significant but also practically meaningful. For example, teachers' mean awareness (about 3.95) is roughly two full scale points higher than sixth graders' mean (1.91), indicating that teachers on average know "very well" what sixth graders have "never heard of." Attitude differences, while a bit smaller in absolute terms, still show that teachers are, on average, between "agree" and "strongly agree" with pro-renewable statements, whereas sixth graders are closer to a neutral stance. High school students (12th grade) are an interesting intermediate group: their mean attitudes (3.27) suggest general agreement that renewables are good, but not as enthusiastically as the teachers (3.90).

In addition to the Likert-scale outcomes, the survey included a few direct questions for teachers to gauge their perspective on renewable energy education. We found that 85% of the teacher respondents answered "Yes" to the question "Do you think renewable energy topics should be incorporated into the school curriculum?" This high level of support among teachers is consistent with the generally positive attitudes observed on the Likert-scale measure. However, when asked "Do you feel you have sufficient training or knowledge to effectively teach topics related to renewable energy?", about 52% of teachers responded "No" (the rest saying "Yes" or "Not sure"). This means that roughly half of the teachers, despite their favorable view of including renewables in education, expressed a need for additional training or knowledge upgrade to teach these topics confidently. This finding has important implications which we will address in the Discussion and Conclusion sections.

Relationship Between Awareness and Attitudes (RQ3)

To test H3, we examined the Pearson correlation between awareness and attitude scores within the student group and within the teacher group. For students (combined across 6th, 9th, and 12th grades; n = 360), For students (combined across Grade 6, Grade 9, and Grade 12; n = 360), awareness was positively associated with attitudes (r = .72, p < .001). This indicates that students who knew more about renewable energy tended to also feel more positively inclined towards it.

In practical terms, a student who rated themselves as very knowledgeable about many renewable sources was very likely to agree with pro-renewable statements, whereas a student who had heard of few or none of the sources often had a neutral or indifferent attitude. Visual inspection of the awareness and attitude score distributions indicated an approximately linear association without extreme outliers.

For teachers (n = 180), the correlation between awareness and attitude was weaker but still statistically significant: $r = 0.27$, $p = .004$ (significant at the 0.05 level). This positive correlation implies that even among teachers, those with higher self-reported knowledge of renewable energy tended to have slightly more positive attitudes. However, the magnitude of this association is much smaller than in students. Table 2 shows the Pearson correlation coefficients between renewable energy awareness and attitudes within each group.

Table 2

Pearson Correlations Between Renewable Energy Awareness and Attitudes Within Students and Teachers

Group	n	r	p
Students (6th, 9th, 12th combined)	360	.72**	< .001
Teachers	180	.27*	.004

*Note: Pearson's r reflects the association between awareness and attitude scores within each group (two-tailed). *p < .05. **p < .001. A Fisher's z test comparing the two correlations indicated a stronger association among students than among teachers (z = 6.87, p < .001).*

As Table 2 shows, for students the correlation (0.72) is in the "high" range, whereas for teachers the correlation (0.27) would be categorized as "small to moderate." A formal comparison of these two correlation coefficients (using Fisher's z transformation) confirmed that the student correlation is significantly higher ($z \approx 6.87$, $p < .001$) than the teacher correlation. This suggests that knowledge and attitudes are more tightly coupled for students than for teachers. Possible interpretations for this difference will be explored in the Discussion section. Both groups showed positive awareness–attitude associations, with a substantially stronger relationship among students than among teachers.

Discussion

This study examined renewable energy awareness and attitudes among Arab students and teachers in northern Israel, and tested whether awareness is associated with more favorable attitudes within each group. Across outcomes, awareness and attitudes increased consistently with educational level, with teachers reporting the highest scores. Awareness and attitudes were strongly linked among students and more modestly linked among

teachers, a pattern that is consistent with the idea that attitudes in younger respondents track current knowledge more closely, whereas adult attitudes may reflect additional influences beyond factual familiarity.

Overall Levels of Awareness and Attitudes

We hypothesized (H1) that awareness and attitudes would be "moderate at best," especially among students. This was borne out by the data. Grade 6 students, in particular, had low mean awareness (approximately 1.9 on the 1–5 scale) and only mildly positive attitudes (~2.2). Even the older students did not exhibit very high knowledge; for example, 12th graders averaged around 3.4, meaning that on some renewable topics they were knowledgeable but on others they were still unsure or uninformed. Teachers were the only group approaching a high level of awareness (mean ~3.95, just shy of "know it very well"). Attitudinally, none of the groups averaged the maximum, and student groups in particular were closer to neutral-positive than to strongly pro-renewable.

These results are consistent with observations in other educational contexts. As noted in the literature review, moderate knowledge levels seem common among students. For instance, Agung Pambudi et al. (2024) reported that Indonesian high schoolers knew only ~57% of what was asked about renewable energy, which parallels the moderate scores we see in our student sample.

Shehzad et al. (2023) contended that many students finish school without a robust foundation in renewable energy concepts; our findings echo this concern, showing that without a dedicated curriculum, students' awareness remains limited. In our case, Arab 6th graders had effectively no exposure to certain renewable concepts (many had "never heard" of terms like biomass or geothermal energy, based on item-level responses). This mirrors Shehzad et al. (2023) critique that renewable energy education is too often absent at the elementary level, resulting in young learners who simply haven't encountered the topic in any depth.

Attitudes among our students were also tepid, which aligns with what might be expected when knowledge is shallow. Other studies have similarly found that youth who are not well-informed tend to express only cautious support for environmental initiatives. Cole et al. (2023), for example, examined elementary students' perceptions of solar energy and found that prior to an educational intervention, many students were unsure or only vaguely positive about solar power. They might agree that "solar energy is good" in principle, but they had little understanding of why, and some harbored misconceptions (e.g., thinking solar panels work at night or are limitless in output). After a hands-on learning experience (visiting a "learnscape" with solar installations), those students' attitudes improved markedly alongside their knowledge. This suggests that education can turn tentative approval into enthusiastic support. Our study's cross-sectional snapshot likely captured students *before* any systematic renewable energy education, hence the moderate attitudes. It stands to reason that a well-designed educational program in these Arab schools could elevate both awareness and enthusiasm, as happened in Cole et al.'s intervention.

It is also worth noting that moderate attitudes could be influenced by the sociocultural context of our participants. In Arab communities in Israel, environmental issues have not

traditionally been front-and-center either in the public discourse or in the school curriculum (Dallasheh & Zubeidat, 2023). The urgent issues perceived by these communities might be more along the lines of educational equity, employment, or political concerns, rather than climate change or renewable energy. Thus, students' ambivalence might reflect a sense that renewable energy is a distant or low-priority issue.

Moreover, language barriers (Ganayim, 2023) mean that Arab students might not access Hebrew-language media campaigns or informal science learning opportunities that their Jewish peers do; this can lead to lower baseline awareness. Indeed, a lack of Arabic-language resources on environmental science could directly result in Arab students (and even teachers) being less informed or engaged—something that initiatives in recent years are trying to address through translations and bilingual programs.

Teachers in our sample had generally positive attitudes (mean ~3.9, nearing "agree" on pro-renewable statements), but even among them, the attitude level was not uniformly at the maximum. About 15% of teachers gave neutral or even slightly negative responses to some attitude items (like skepticism about the reliability of renewables or priority of other issues). This indicates that while the majority are on board with the concept of renewable energy, a few remain unconvinced or less enthusiastic.

In a way, this is not surprising: attitudes are shaped by more than just knowledge, including personal experiences, cultural values, and perceived feasibility. Some teachers, especially older ones, might be accustomed to traditional energy paradigms or simply feel that issues like student discipline or core curriculum are more pressing than adding new topics like renewable energy. This nuance underscores that awareness is necessary but not always sufficient for full buy-in—an observation well documented in environmental psychology (knowledge often predicts attitude, but the correlation is far from perfect, as we saw in our teacher group's case).

In summary, the moderate baseline levels we observed affirm the need for better integration of sustainability topics into the education of minority communities. The Arab students in our study are not lagging out of lack of capability or interest, but likely out of lack of exposure and emphasis. Their moderate attitudes should be seen as an *opportunity*: with their minds not yet made up strongly for or against, a targeted educational push could tilt the balance towards strong pro-environmental attitudes.

Differences by Educational Level and Role (Students vs. Teachers)

The results for H2 showed a very clear progression: as education level increases, so do awareness and positive attitudes. Sixth graders were the least knowledgeable and least positive, and each step up (to 9th, 12th, and then teachers) showed significant gains. This stepwise pattern is consistent with developmental expectations and prior research. Older students have had more years of schooling, more exposure to science content, and more cognitive maturation, all of which are likely to contribute to their better performance on the awareness scale. Additionally, older students might have had opportunities to learn about environmental issues through extracurricular activities, media, or personal reading—opportunities that younger ones haven't yet encountered.

Our findings align with those of Agung Pambudi et al. (2024), who found that educational level was a key determinant of renewable energy knowledge in Indonesia. In their work, high schoolers in specialized technical programs knew more about renewables than those in general programs, and both knew more than younger students. Similarly, general surveys often show that adults (especially those with higher education) outscore teenagers on environmental knowledge quizzes. Our teacher–student contrast supports this: teachers (all of whom had higher education and life experience) scored highest of all.

Beyond pure knowledge, the attitude differences also followed the educational hierarchy. One might ask whether the pattern reflects knowledge effects, age-related developmental differences, or both. In a cross-sectional design, causal direction cannot be established, but the most parsimonious interpretation is cumulative exposure. Older students and teachers have had more years of schooling and more opportunities to encounter energy and environmental topics through science coursework, media, and everyday discourse. In addition, older students may engage with the topic using more advanced reasoning skills, which can translate into higher self-reported familiarity and more stable evaluative judgments. These explanations are consistent with the observed stepwise differences, without requiring unmeasured assumptions about cohort-specific historical events or generational shifts.

Teachers had more education and thus more knowledge, leading to more confidence in and support for renewables; students were in earlier stages of that journey. Notably, the differences between adjacent student groups (6th vs 9th, 9th vs 12th) were statistically significant for both awareness and attitudes. This is reassuring from an education standpoint—it suggests that even within our sample, schooling between 6th and 9th grade, and between 9th and 12th, did correspond with improvements in understanding and perspective on renewables. We cannot claim a causal effect (many other factors differ as children age), but it hints that the schooling process itself, even without a formal sustainability curriculum, imparts some relevant knowledge.

Possibly, general science classes, discussions of current events, or informal science education as students get older contribute to these gains. Another factor is simply cognitive development: by 9th grade, students can grasp abstract concepts better than in 6th grade, and by 12th grade, they can engage in more critical thinking, which might lead to higher awareness and more formed opinions on issues like energy. It is interesting that for attitudes, the gains were roughly parallel to those for knowledge. This suggests that attitude formation is tracking knowledge acquisition to a considerable degree.

The literature supports this parallel; for example, a Hungarian study Szakály et al. (2020) found that younger people not only knew less about renewables but were also less favorable towards them, and they posited that increasing education could improve both metrics in tandem. In our data, the correlation analysis further backs up the link (especially in students): where knowledge is higher (as in older groups), attitudes are more positive. We will discuss correlation specifically in the next subsection, but it's worth noting here that the group differences and the correlation together paint a coherent picture: education and knowledge seem to foster more pro-renewable attitudes.

Our inclusion of teacher perspectives, especially the additional survey questions about curriculum, yielded an important practical insight: teachers overwhelmingly want

renewable energy taught in schools (85% support), but half feel underprepared to teach it. This resonates with findings from other contexts. For example, a study of teachers in the UAE by AlKaaki et al. (2032) noted that while most teachers agreed sustainability is important, many had never received formal training on the topic and thus didn't incorporate it in class. Hoque et al. (2023) Similarly argue that professional development is crucial for empowering teachers to use mobile labs and other tools for renewable energy education. Our teacher respondents, being part of a minority education sector, likely have had even fewer training opportunities in these areas. The implication is clear: if educational authorities wish to improve student outcomes in renewable energy literacy in Arab schools, they should invest in teacher training and resources. The willingness is there among teachers, according to our data; what's needed is capacity building.

Finally, it's worth reflecting on the magnitude of differences we observed. Teachers' awareness of being almost two whole points higher than 6th graders on a 5-point scale is a large gap, bigger than one might find for some other topics. For example, if this were a general science knowledge test, we might not see such a dramatic difference (many 6th graders know some science facts and some teachers have forgotten specifics). The fact that we do see such a difference for renewable energy suggests that exposure to this topic is heavily cumulative and skewed toward higher education levels. Renewable energy might not appear at all in early curricula, appears somewhat in middle school (perhaps in geography or general science by 9th grade), and more in high school (maybe in environmental science electives or physics contexts by 12th grade). Teachers, by virtue of either personal interest or college coursework, have filled in a lot of gaps. This pattern reinforces why formal inclusion at earlier stages could lift the floor—closing the gap so that younger students aren't left so far behind in understanding a critical global issue.

The Knowledge–Attitude Relationship

Our third hypothesis (H3) anticipated a positive correlation between awareness and attitudes, which we found evidence for in both groups, with an especially strong link in students. This aspect of our findings speaks to the classic debate in environmental education: does knowing more make you care more? For students, the answer from our data seems to be yes, quite strongly. The correlation of $r \sim 0.72$ in students is high for social science data, suggesting that knowledge and attitude go together for this group. It implies that many students who lacked awareness also showed indifferent attitudes, and conversely those who were informed were quite supportive of renewables. This correlation aligns with the Knowledge–Attitude–Behavior (KAB) model as originally conceived in the environmental context. Young learners often form opinions as they learn; when a concept is unfamiliar, they have little basis to feel strongly about it. As they gain understanding, they start to appreciate the importance or develop an emotional connection to the idea, which in this case is the need for clean energy.

Literature provides parallel examples. In their analysis of survey data, Szakály et al. (2020) noted that in Hungary, those with higher objective knowledge about renewables tended to have more positive attitudes, particularly among the youth demographic. They pointed out that misinformed individuals were sometimes wary or skeptical of renewables (e.g., some believed solar panels were far more expensive or less efficient than they are, tempering their support). Educational interventions that corrected these misconceptions

often led to improved attitudes (Szakály et al., 2020). Our student data similarly suggest that ignorance may breed indifference, whereas learning can breed optimism or approval. This underscores a hopeful message: boosting education on renewables might directly translate into a more supportive young citizenry for sustainability transitions.

The teacher group's weaker correlation ($r \sim 0.27$) invites analysis. Why would teachers' attitudes not correlate with knowledge as much as students' do? One reason could be a ceiling effect: teachers mostly have high knowledge (scores clustered 3.5–5) and high attitudes (mostly 3–5), with relatively restricted range. Statistically, restricted range can dampen correlation. It might simply be that there wasn't as much variation left to observe; nearly all teachers know the basics (so awareness doesn't differ hugely among them), and nearly all already think renewables are good (so attitude doesn't differ hugely either), making the correlation mathematically lower. This interpretation fits with the fact that teachers' awareness was generally very high and their attitudes quite positive.

Another angle is the possibility that teachers' attitudes are influenced by additional factors beyond awareness. By the time someone is an adult and an educator, their attitudes toward things like renewable energy might be shaped by their broader worldview, political ideology, or practical considerations (e.g., a teacher who is also a primary breadwinner might worry about the economic costs of transitioning to renewables, even if they personally understand the environmental need). Some teachers may also recall outdated or conflicting information from when they were trained, which could influence their stance independently of how many facts they know now. In contrast, students likely have more malleable attitudes that shift as they learn new facts in real time, with fewer entrenched preconceptions.

Interestingly, the weaker knowledge–attitude link for teachers might mirror findings in general adult populations. Research often shows that for adults, environmental attitudes correlate with knowledge but not as strongly as one might think; values, peer influence, and media narratives also play a big role. For example, some adults are well aware of climate science but politically oppose certain green policies for economic or ideological reasons—their attitudes diverge from pure knowledge. In our case, while we didn't measure such complexities, it's plausible that teacher attitudes were near-positive regardless of subtle differences in knowledge, leading to a modest overall correlation.

In practical terms, the strong student correlation suggests that improving students' knowledge could be a highly effective way to improve their attitudes. This is encouraging because knowledge is something educators can directly target through curriculum and instruction. The teacher correlation being smaller suggests that simply giving teachers more facts might not dramatically change those few who aren't already on board; instead, addressing attitudes at the teacher level might require different approaches (e.g., professional dialogues, field experiences, emphasizing the relevance and success stories of renewables to win hearts, not just minds). Fortunately, as noted, most teachers are already supportive—so the main task is empowering them with skills, rather than changing their attitudes.

Another nuance from our data is that sixth graders showed a curious pattern: their mean attitude (2.21) was a bit higher than their mean awareness (1.91). This implies that some very uninformed young students still expressed slightly positive attitudes—perhaps reflecting a baseline "environmental goodwill" even if they didn't know specifics. Young children often have generally positive feelings about nature or clean energy simply because

they've been told such things are "good" in a moral sense, even if they can't elaborate. By ninth grade, awareness had grown and attitudes rose accordingly, and by 12th grade, awareness slightly outpaced attitude (3.36 vs 3.27). That subtle switch (awareness surpassing attitude) in the oldest students could hint at increasing realism or critical thinking: some well-informed 12th graders might acknowledge pros and cons of renewables, thus not giving uniformly high attitude ratings despite high awareness.

This is speculative, but research does show that older adolescents become more nuanced in opinions—some might say "Yes, I know a lot about solar energy, but I'm aware it's intermittent and that could be a problem, so I'm not 100% positive about it." In contrast, someone who knows just a little might be unabashedly positive because they focus only on the ideal ("solar = good because it's clean") without knowing challenges. Thus, ironically, increased knowledge can sometimes introduce complexity that tempers attitude—though in our sample the overall direction was still that more knowledge aligned with more positivity.

Conclusion

This study provides baseline evidence on renewable energy awareness and attitudes among Arab students and teachers in northern Israel. Awareness and attitudes increased steadily from Grade 6 to Grade 12 and were highest among teachers, indicating that exposure through schooling and professional experience likely accumulates over time. Awareness was closely tied to attitudes among students, whereas the association was smaller among teachers, suggesting that knowledge-based instruction may be especially influential for younger learners while teachers' views may reflect additional influences beyond familiarity alone. The findings support earlier, structured integration of renewable energy concepts in Arabic-language school settings, alongside targeted professional development that equips teachers with classroom-ready materials and pedagogical strategies. Future research can strengthen inference by including objective knowledge measures, broader sampling across regions, and longitudinal or intervention designs that track change in both awareness and attitudes.

The pattern of findings suggests that sustainability education in Arab schools may benefit from earlier and more systematic attention to renewable energy concepts, using materials that are linguistically accessible and culturally relevant. Given teachers' strong support for curriculum integration alongside reported training needs, professional development that combines content knowledge with classroom-ready activities may be particularly valuable. Instruction that connects renewable energy to locally meaningful examples, school-based projects, and everyday decisions may help translate awareness into more favorable attitudes among students, especially in the earlier grades where baseline familiarity appears lowest.

This study has several limitations: reliance on self-reported awareness may have introduced bias and should be complemented in future work by objective knowledge measures (e.g., quizzes) to test alignment between perceived and tested understanding (Szakály et al., 2020); the non-random sample drawn from Arab schools in northern Israel limits generalizability to other regions, communities, and minority contexts, suggesting the value of broader regional sampling, Arab–Jewish comparisons, and cross-national comparisons to examine the influence of sociocultural and political context; the cross-

sectional design prevents causal inference, so longitudinal studies are needed to clarify the directionality and co-development of knowledge and attitudes over time; attitude measurement remained broad and did not capture the reasons and narratives underlying participants' views, which qualitative methods such as interviews and focus groups could illuminate for both students and teachers; and finally, because the study assessed awareness and attitudes but not behavior, future research should examine whether these elements translate into concrete actions among students and into classroom practice among teachers, completing the pathway from knowledge and attitudes to behavior and implementation.

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Ethical Approval. We hereby confirm that the research presented in the manuscript titled: "Attitudes and Awareness of Renewable Energy Sources among Arab Students and Teachers in Elementary, Middle, and High Schools" Was conducted in full compliance with institutional and national ethical standards. The study received formal approval from the Institutional Ethics Committee of The Arab Academic College for Education in Israel, which reviewed and authorized all procedures related to data collection, participant consent, and confidentiality.
Consent to Participate. Written informed consent was obtained from the legal guardians of all participating students. School administrations also granted authorization for conducting research.
Consent to Publish. Consent for publication of anonymized data was obtained from the participants' legal guardians and the respective school administrations.
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