Effect of a Climate Change Educational Program on University Students' Knowledge, Attitudes, and Practices

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Abstract

Background: Climate change impacts human lives and health by threatening the essential ingredients of good health such as clean air, safe drinking water, nutritious food supply, and safe shelter. It has the potential to undermine decades of progress in global health. **Aim of the study**: to evaluate the effect of the Climate Change Educational Program on University Students' Knowledge, Attitudes, and Practices. **Subjects and Methods**: This quasi-experimental study was conducted in Mansoura and Fayoum Universities on 200 university students. A self-administered questionnaire was used for data collection, with three scales to assess their knowledge, attitude, and reported practice. **Results**: Students were mostly females (65.5%), with a rural residence (67.0%). Their pre-intervention knowledge was deficient, and their attitudes and reported practices were variable. Statistically significant improvements were revealed in their post-intervention knowledge, attitudes, and practices (p<0.001), with slight declines in their follow-up knowledge and attitudes, but a rise in their practices. Their knowledge, attitudes, and practice scores are positively correlated. In multivariate analyses, the educational program was the main positive predictor of the knowledge scores, the knowledge scores were the positive predictors of the attitude scores, and the attitude and knowledge scores were positive predictors of the practice scores. **Conclusion and Recommendations**: The educational awareness-raising program is effective in improving university students' knowledge, attitude, and reported practices regarding climate change. Considerable work is required to integrate climate change concepts into the university curricula. The developed program and booklet could serve as a basis for further educational interventions.

Keywords: Attitudes, Climate change, Educational program, Knowledge, Practices University students.

Introduction

Climate change, an increasingly pressing global issue, has far-reaching implications for human health. Global Warming (GW) refers to the evolving temperature rise on Earth's surface **(National Aeronautics and Space Administration [NASA], 2021)**. Greenhouse Gases (GHGs) such as CO_2 and methane naturally exist in the atmosphere and facilitate keeping the Earth's surface heat enough to sustain life **(Climate Hubs U.S. Department of Agriculture USDA Climate Hubs, 2021)**. The recent and ongoing increase in the average temperature of the Earth's surface and oceans has negative environmental impacts that can affect human health and life **(United States Environmental Protection Agency EPA, 2021)**.

According to climate scientists, human and man-created activities are the main cause of global warming **(National Aeronautics and Space Administration [NASA],2021)**. As rising temperatures, changing precipitation patterns, and extreme weather events become more common, they bring about a range of health consequences, including the proliferation of vector-borne diseases, respiratory issues due to air pollution, and heat-related illnesses. Other expected consequences are higher sea and lower potable water levels, with agricultural problems leading to food insufficiency and economic problems **(National Centers for Environmental Information [NOAA], 2022)**. Understanding and addressing these impacts is

crucial for developing effective public health strategies and fostering a resilient society **(Ramadani et al., 2023)**.

Egypt is one of the extremely vulnerable countries to climate change and global heating with its economic, social, and environmental threats **(United Nations Development Programme [UNDP], (2020)**, and negative impacts on people's health **(International Journal of Environmental Studies, 2022)**. A report from the Egyptian Meteorological Service showed an unprecedented rise in temperatures five years ago, with temperatures rising by an average of 3-4 degrees Celsius above normal. This prompted the Egyptian government to take more serious and effective actions, programs, and policies to adapt to emerging climate changes and to counter its negative impacts on various economic sectors. Collaboration and coordination of efforts were recently set between ministries of environmental affairs, health, education, and other nongovernmental agencies to improve related awareness, attitudes, and practices **(Al-Ahram Center for Political & Strategic Studies, 2021)**. Moreover, Egypt hosted the 27th session of the Conference of States Parties to the United Nations Convention on Climate Change (COP 27) **(Enterprise Ventures,2022)**.

Understanding the direct and indirect health impacts of climate change is fundamental for informed decision-making. University students, as future leaders and influencers, have a pivotal role to play in driving and leading societal change and innovation. Their awareness and understanding of the health consequences of climate change can significantly impact their personal choices and future professional practices. Awareness programs are designed to bridge knowledge gaps, shape attitudes, and encourage behavior that aligns with better health outcomes and climate resilience **(Albrecht et al., 2023)**. Empowering university students with the knowledge, attitudes, and behaviors necessary to address and mitigate the health consequences of climate change, thereby contributing to a healthier and more sustainable future **(Blanchard et al., 2023)**.

Educational programs are often designed to translate knowledge and attitudes into concrete actions and behaviors. Such programs could lead to tangible changes in students' behaviors, contributing to broader public health and environmental goals. However, evaluating how awareness programs affect students' knowledge can reveal gaps in current educational approaches and highlight areas for improvement. Attitudes toward climate change and its health consequences influence how individuals prioritize and respond to these issues. Furthermore, behavioral change is essential for mitigating the health impacts of climate change **(Chevance et al., 2023)**.

Nurses have a high level of recognition and trust within society, with professional ethics to handle considerations of their different community setting and forestall adverse health outcomes. Climate change and environmental problems could be of major concern to them **(GülırmakGülerand Albayrak Günday, 2024)**. Public health nurses have a broader view of population health and thus support the implementation of awareness programs and policies aimed at improving physical and social environments at the local, national, and international levels **(Toor et al., 2021)**. However, despite the growing recognition of climate change's health effects, there is often a detachment between scientific knowledge and personal or collective action. Awareness programs have the potential to address this gap by providing critical information and fostering a proactive mindset **(Lemke et al., 2023)**.

Significance of the study

Climate change is a major threat to human health. Therefore, healthcare systems must address this issue for its global consequences. The rationale for this study is based on the need to test the effectiveness of climate change educational programs for university students. It can thus provide insights into awareness strategies and provide useful recommendations for enhancing their effectiveness.

Aim of the study

This study aimed to evaluate the effect of Climate Change Educational Program on University Students' Knowledge, Attitudes, and Practices.

Research hypothesis: The implementation of the health education program will lead to

significant improvements in university students' knowledge, attitudes, and practices regarding climate change.

Subjects and Methods

Research design and settings: A one-group quasi-experimental research design with pre-post assessment was used in conducting this study. It was carried out in Mansoura and Fayoum Universities. Mansoura University is one of the oldest universities in Lower Egypt, whereas Fayoum University is a newer one and is located in Upper Egypt.

Subjects: The study population consisted of university students enrolled in Mansoura and Fayoum Universities during the academic year 2023/24. All students were eligible for inclusion in the study sample, with no exclusion criteria. The sample size was calculated to detect an improvement in students' scores of knowledge, attitude, and reported practice with a moderate effect size (Odds Ratio 2.0) according to **Chinn (2000)**. Using the G*Power software package, Version 3.1.9.4 at a 95% level of confidence and 80% power, the required sample size was 164. Considering an expected dropout rate of around 15%, the sample size was increased to 200 students.

Sampling technique: A multi-stage stratified sampling technique was used to recruit students in the study sample. In the first stage, the faculties in the two universities were categorized into applied and theoretical sciences. From each category, two faculties were selected. These were the faculties of nursing and sciences from the applied category, and the faculties of commerce and special education from the theoretical category. The total sample size was equally divided into four to include 50 students from each of the four selected faculties. These were recruited by convenience sampling.

Data collection tool: A self-administered questionnaire was used for data collection. It was designed by the researchers based on relevant literature **(Lowe, 2006; Leviston et al., 2013; EU, 2014; Manuti, 2013; Leviston et al., 2014; Kwok, 2019)**. The tool was in Arabic language and included a section for student's demographic and personal data such as age, gender, marital status, residence, income, etc. in addition to some academic information such as the type of pre-university education and previous failure, as well as certain health-related information such as having chronic diseases, smoking, and practice of exercise. The questionnaire also included three different scales to assess student's knowledge, attitude, and reported practice.

Knowledge scale: This consisted of 36 questions testing respondents' knowledge of climate components, change, affecting factors, manifestations, consequences, effects on water, prevention, and most affected people. It included ten True/False questions,12 multiple choice questions (MCQ), in addition to 8 open-ended questions. For scoring, each question correctly answered was scored one point, and the incorrect zero. The scores of each dimension and the total scale were summed up and converted into percentage scores. The knowledge was considered satisfactory if the score was 60% or more and unsatisfactory if less than 60%.

Attitude scale: adopted from standardized scale This comprised 20 statements assessing respondents' attitudes towards climate change causes, importance, personal vulnerability, concerns, personal role, and support. The response was on a 3-point Likert-type scale "agree/ uncertain/disagree." The scale had positive items such as "I feel an ethical obligation to do something regarding climate change," as well as negative items such as "I do not think I am exposed to risks due to climate change." For scoring, the items checked "agree" "uncertain", and "disagree" were respectively scored 2, 1, and zero. The scoring was reversed for the negative statements so that a higher score indicates a more positive attitude. The scores of each dimension and the total scale were summed up and converted into percentage scores. The student's attitude was considered positive if the score was 60% or more and negative if less than 60%.

Reported practice scale: This scale had 30 statements asking about students' practices reflecting energy saving, using environment-friendly things, recycling, and waste reduction such as: "I prefer walking rather than riding," "I prefer to buy environment-friendly products," "I segregate waste." The response to each item

was on a 4-point Likert-type scale "always/often/rarely/never." The responses to these items were respectively scored 3, 2, 1, and zero. The scores of each dimension and the total scale were summed up and converted into percentage scores. The student's reported practice was considered adequate if the score was 60% or more and inadequate if less than 60%.

Validity and reliability: The research instrument was face and content validated by three experts in community health nursing and two experts in psychiatric health nursing. They thoroughly reviewed the questionnaire form for relevance, clarity, and comprehensiveness. All corrections and constructive comments raised by the experts were taken into consideration in the preparation of the final version of the instrument. The reliability of the scales was assessed by testing their internal consistency. They demonstrated high reliability with a Guttman split-half coefficient of 0.79 for the knowledge scale, and Cronbach's Alpha coefficients of 0.87 and 0.90 for the attitude and practice scales.

Pilot study: A pilot study was conducted before the start of data collection to ensure full clarity and applicability of the tool and feasibility of the study. It was carried out on 20 students representing 10% of the main study sample. Although no modifications were made, the pilot sample was excluded from the main study sample to avoid bias given the interventional nature of the study.

Fieldwork: The study was conducted through assessment, planning, implementation, and evaluation phases.

Assessment phase: In this phase, the researchers recruited the study sample using the stratified sampling technique. The data collection forms were distributed to students and the researchers provided them with the instructions for filling it. The researchers were present all the time to respond to any queries and to prevent any communication among students while filling in the forms to avoid bias. The filled forms were collected and revised for the completion of the identification data. The data obtained during this phase constituted the baseline information or pretest.

Planning phase: The researchers used this phase to design the educational program and prepare the booklet to be provided to the students participating in the intervention. The program was developed based on the student's needs identified from the pretest data, in addition to researchers' experience, opinions of medical and nursing experts, and pertinent literature. It was aimed at providing students with sound knowledge and proper practices toward climate change.

The program and booklet were designed to address climate change and global warming. It was aimed at improving students' knowledge, attitudes, and practices regarding climate change meaning, major environmental problems, accelerated global warming, the gases aggravating climate change, related health impacts, and the dangers of the increase of carbon dioxide in the atmosphere, the greenhouse gases that allow solar radiation to pass back into space, the ways for eliminating climate change, and the use of solar energy. It also involved issues such as the most affected people, Also, the program addressed university students' attitudes and concerns towards climate change, their related optimism, and their sense of responsibility and commitment. It also involved students reporting indoor and outdoor practices that could affect climate change.

Implementation phase: In this phase, the researchers started program sessions in small groups of 20-25 students. The program consisted of seven sessions over two weeks, for a total of 14 hours. Sessions lasted 45-60 minutes. Various teaching resources and media were used such as videos, mini-lectures, and open discussions with questions and answers. The developed booklet was distributed to students to help them in their learning process, and as a further reference after the end of the program.

Evaluation phase: The effect of the intervention was measured immediately after the end of the program as a posttest and was repeated after four months for follow-up. The same data collection instrument and the process used in the pretest were applied at both post and follow-up tests.

Ethical considerations:

The study protocol was approved by the Ethics Committee at the Faculty of Nursing, Fayoum University. Approvals to conduct the study were obtained from the Deans of the selected faculties using official channels with an explanation of the aim of the study and its procedures. Each student was informed about the purpose and benefits of the study, and about the right to refuse participation or to withdraw at any time with no need to explain. Verbal consent was obtained from each student who agreed to participate before starting the data collection. Strict confidentiality and anonymity were ensured during the processes of data collection and data management.

Statistical analysis: The SPSS 20.0 statistical software package was used in data management. Categorical variables were presented in frequencies and percentages, while numeric ones were presented as means, standard deviations, and medians. Pearson or Spearman rank correlations were used as suitable. Multivariate analysis in the form of multiple linear regression was used to identify the predictors of the changes in students' knowledge, attitude, and practice.

Results

The study sample consisted of 200 university students with a median age of 20 years, mostly females (65.5%), with rural residence (67.0%) as presented in Table 1. The majority had a general pre-university education (77.5%) and had access to the internet (80.5%). Only 28.0% reported practicing exercise, and 3.5% were smokers.

Table 2 points to generally deficient students' knowledge about climate change in the pre-intervention phase, where none of them had satisfactory knowledge about the consequences of climate change, the most affected people, and the situation in Egypt. Statistically significant improvements were shown in the post-intervention phase (p<0.001), reaching 98.0% regarding the affecting factors. The improvements continued through the follow-up phase although with some slight declines.

Concerning students' attitudes, Table 3 demonstrates a wide variability in the pre-intervention phase. Thus, the percentages of positive attitudes ranged from 18.5% for personal vulnerability to 91.0% for importance. The post-intervention phase showed statistically significant improvements in all dimensions (p<0.001), reaching 98.0% regarding the affecting factors. The attitudes continued to improve at the follow-up phase despite some small declines.

The table also indicates that more than one-half of the students had adequate pre-intervention reported practices, the highest being related to energy saving (60.0%). Their practices significantly improved in the post-intervention phase, except for the practices regarding using environment-friendly things, which slightly but not significantly improved (p=0.36). The improvements continued through the follow-up phase, with statistically significant differences in all four dimensions.

In total, Figure 1 demonstrates that only 1.5% of the students had pre-intervention satisfactory knowledge, which rose to 93.5% in the post-intervention phase. Similarly, the percentage of students with positive attitudes increased from 35.5% to 89.5%, and with positive reported practices from 60.0% to 91.0%. The follow-up phase was associated with slight declines in the percentages of satisfactory knowledge and positive attitude, but with a rise in the percentage of adequate reported practice, reaching as high as 95.0%.

Table 4 demonstrates a statistically significant strong positive correlation between students' scores of knowledge and attitude (r=0.817). Moreover, their reported practice scores had statistically significant moderate positive correlations with their scores of knowledge and attitude. The table also points to statistically significant weak negative correlations between students' scores of knowledge and attitude from one side and their academic year and age from the other side. Meanwhile, their attitude and reported practice scores had statistically significant weak positive correlations with their income level.

The multivariate analysis (Table 5) identified the study intervention as the main statistically significant independent positive

predictor of students' knowledge scores. Meanwhile, the academic year, female gender, and income were additional positive predictors, while being in an applied sciences faculty was a negative predictor. The model explains 76% of the improvement in the knowledge score.

As regards the attitude score, the table indicates that the knowledge score was its main statistically significant independent positive predictor, in addition to income. These two factors explain 59% of the improvement in the student's attitude scores.

Lastly, concerning the reported practice scores, the table shows that the attitude and knowledge scores were its main statistically significant independent positive predictors, in addition to urban residence, income, and practice of exercise. Conversely, being married and having a personal computer (PC) were negative predictors. The model explains 22% of the improvement in the reported practice score.

Table (1): Personal characteristics of students in the study sample (n=200)

Items	Frequency	Percent
Age:		
<21	132	66.0
21+	68	34.0
Range	18-24	
Mean±SD	20.1±1.1	
Median	20.0	
Gender:		
Male	69	34.5
Female	131	65.5
Married	16	8.0
Residence:		
Rural	134	67.0
Urban	66	33.0
Sufficient family income	106	53.0
Pre-university education:		
General	155	77.5
Technical	45	22.5
Previous academic failure	40	20.0
Have:		
PC	82	41.0
Internet	161	80.5
Had training in courses in environment	39	19.5
Attended lectures in environment	74	37.0
Have chronic diseases	41	20.5
Smoking	7	3.5
Practice exercise	56	28.0

Table (2): Students' knowledge regarding climate change throughout the intervention phases(n=200)

Items	Time						X^2 (Pre-post)	X^2 (Pre-FU)
	Pre		Post		FU			
	No.	%	No.	%	No.	%		
Satisfactory Knowledge (60%+)								
Components	38	19.0	188	94.0	187	93.5	228.87 (<0.001*)	225.53 (<0.001*)
Climate change	147	73.5	183	91.5	189	94.4	22.44 (<0.001*)	32.81 (<0.001*)
Affecting factors	135	67.5	196	98.0	196	98.0	65.17 (<0.001*)	65.17 (<0.001*)
Manifestations	13	6.5	177	88.5	139	69.5	269.63 (<0.001*)	168.46 (<0.001*)
Consequences	0	0.0	167	83.5	137	68.5	286.70 (<0.001*)	208.37 (<0.001*)
Effects on water	79	39.5	185	92.5	187	93.5	125.18 (<0.001*)	130.89 (<0.001*)
Prevention	2	1.0	172	86.0	141	70.5	293.97 (<0.001*)	210.29 (<0.001*)
Most affected people	0	0.0	176	88.0	138	69.0	314.29 (<0.001*)	210.69 (<0.001*)
Egypt situation	0	0.0	172	86.0	141	70.5	301.75 (<0.001*)	217.76 (<0.001*)
Justice	126	63.0	191	95.5	189	94.5	64.23 (<0.001*)	59.29 (<0.001*)

Table (3): Students' attitudes and reported practices regarding climate change throughout the intervention phases(n=200)

Items	Time						X^2 (Pre-post)	X^2 (Pre-FU)
	Pre		Post		FU			
	No.	%	No.	%	No.	%		
Positive (60%+) attitude:								
Causes	114	57.0	189	94.5	179	89.5	76.55 (<0.001*)	53.91 (<0.001*)
Importance	182	91.0	194	97.0	194	97.0	6.38 (0.01*)	6.38 (0.01*)
Personal vulnerability	37	18.5	175	87.5	156	78.0	191.13 (<0.001*)	141.78 (<0.001*)
Concerns	155	77.5	187	93.5	181	90.5	20.65 (<0.001*)	12.57 (<0.001*)
Personal role	72	36.0	186	93.0	174	87.0	141.89 (<0.001*)	109.85 (<0.001*)
Support	98	49.0	189	94.5	190	95.0	102.14 (<0.001*)	104.96 (<0.001*)
Adequate (60%+) reported practice:								
Energy saving	120	60.0	183	91.5	194	97.0	54.02 (<0.001*)	81.11 (<0.001*)
Use environment-friendly things	111	55.5	120	60.0	139	69.5	0.83 (0.36)	8.36 (0.004*)
Recycling	116	58.0	175	87.5	186	93.0	43.90 (<0.001*)	66.23 (<0.001*)
Waste reduction	117	58.5	178	89.0	188	94.0	48.05 (<0.001*)	69.59 (<0.001*)

(*) Statistically significant at p<0.05
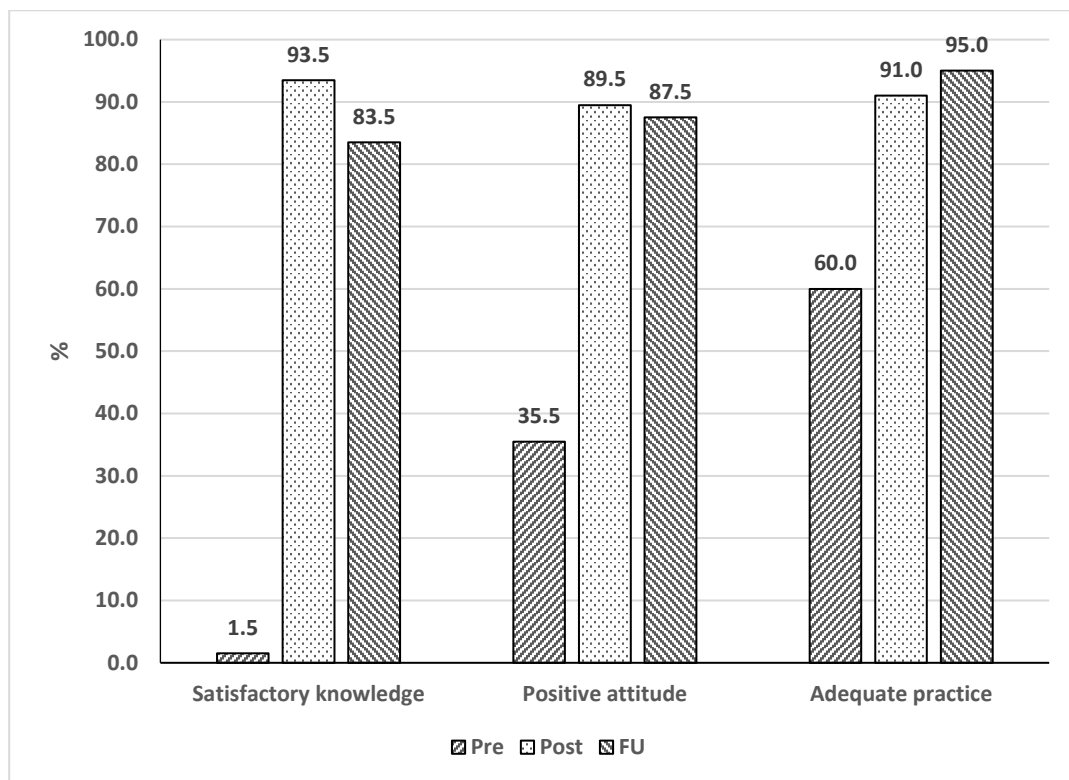
(*) Statistically significant at p<0.05

Figure (1): Students' total knowledge, attitudes, and practices regarding climate change throughout the intervention phases

Table (4): Correlations between students' overall scores of knowledge, attitude, supportive opinion, and practice and their characteristics

Scales	Spearman's rank correlation coefficient		
	Knowledge	**Attitude**	**Practice**
Knowledge	1.000		
Attitude	.817**	1.000	
Practice	.435**	.514**	1.000
Characteristics:			
Academic year	-.098*	-.121**	-.045
Age	-.105*	-.112**	-.022
Failures	-.010	.001	-.028
Income	.020	.086*	.114**

(*) Statistically significant at p<0.05   (**) Statistically significant at p<0.01

Table (5): Best fitting multiple linear regression model for the knowledge, attitude, and reported practice scores

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Knowledge							
Constant	-8.97	3.05		-2.944	0.003	-14.96	-2.98
Intervention	41.48	1.13	0.87	36.589	<0.001	39.25	43.71
Applied sciences faculty	-2.86	1.25	-0.06	-2.279	0.023	-5.32	-0.39
Academic year	1.61	0.67	0.06	2.391	0.017	0.29	2.93
Female gender	3.14	1.20	0.06	2.620	0.009	0.78	5.50
Income	2.60	1.15	0.05	2.265	0.024	0.34	4.86
r-square=0.76 Model ANOVA: F=271.38, p<0.001 Variables entered and excluded: age, marital status, residence, chronic diseases, smoking, exercise, have PC/net, previous fail, training courses							
Attitude							
Constant	43.86	1.54		28.445	<0.001	40.83	46.88
Income	2.41	0.86	0.07	2.789	0.005	0.71	4.10
Knowledge score	0.60	0.02	0.76	29.096	<0.001	0.56	0.64
r-square=0.59 Model ANOVA: F=428.28, p<0.001 Variables entered and excluded: age, gender, marital status, residence, chronic diseases, smoking, exercise, have PC/net, faculty, previous fail, training courses, intervention							
Reported practice							
Constant	57.759	5.453		10.591	<0.001	47.049	68.47
Married	-7.04	2.06	-0.13	-3.413	<0.001	-11.09	-2.99
Urban residence	4.55	1.15	0.15	3.939	<0.001	2.28	6.81
Have PC	-2.74	1.14	-0.09	-2.403	0.017	-4.98	-0.50
Income	2.28	1.01	0.09	2.260	0.024	0.30	4.26
Practice exercise	3.93	1.22	0.12	3.217	0.001	1.53	6.34
Knowledge score	0.09	0.04	0.14	2.162	0.031	0.01	0.17
Attitude score	0.15	0.05	0.19	3.296	0.001	0.06	0.24
r-square=0.22 Model ANOVA: F=16.32, p<0.001 Variables entered and excluded: age, gender, income, have net, previous fail, training courses, smoking chronic diseases, intervention							

Discussion

The present study's research hypothesis was that the implementation of the educational program will lead to significant improvements in university students' knowledge, attitudes, and practices regarding climate change. The results revealed that students' knowledge, attitudes, and practices significantly improved immediately after the implementation of the program, and these improvements were retained at the follow-up phase. The findings thus lead to acceptance of the study's research hypothesis.

According to the current study findings, the university students' knowledge of climate change was very deficient before the intervention, with only three out of the 200 students in the sample having satisfactory total knowledge. The deficiency was mainly related to the consequences of climate change, the most affected people, and the situation in Egypt, as well as its manifestations and related preventive measures. The findings are quite alarming,

especially regarding their lack of knowledge about the situation in Egypt. This would certainly have a negative impact on their attitudes and practices. The finding could be attributed to the lack of educational and health promotion programs addressing the problem in schools and public media. A similarly deficient pretest knowledge was found in a study of the effectiveness of educational interventions about sustainability development among nursing students in Egypt**(Ibrahim et al., 2022)**.

Implementing the current study's educational intervention led to significant improvements in students' knowledge, which was sustained through the follow-up phase. The positive effect of the intervention was confirmed through multivariate analysis, which identified it as the main independent positive predictor of the knowledge score. The success of the program in improving students' knowledge could be due to the meticulous selection of its topics based on their identified needs. Moreover, the program was focused on applied knowledge, which made it more easily assimilated by the students. In agreement with this finding, **Ibrahim et al. (2022)** demonstrated significant improvements in nursing students' knowledge after the implementation of their educational program in sustainability development. On the same line, **Ghazy and Fathy (2023)** in a study of the knowledge of climate change among university students in Egypt reported significant improvements after program implementation.

As regards the factors associated with university students' knowledge of climate change, the present study demonstrated that their pre-intervention scores correlated negatively with their age and academic year. This might be explained by the more attention given to climate issues in recent years, which could have a positive impact on junior-year students. Meanwhile, after the implementation of the study intervention, the multivariate analysis revealed that female students from higher academic years and having higher income had better knowledge, which could reflect more keenness to know about the issue. In congruence with this, a study of climate change behaviors in the United States revealed a significant association between income and socioeconomic conditions and individuals' awareness and attitudes towards climate change **(Magistro et al., 2024)**. On the

other hand, those students from applied sciences faculties had less improvement in their knowledge, which could be explained by their higher awareness about the problem given the nature of their health-related studies, especially in nursing faculties.

The present study has also addressed students' attitudes towards climate change. Before the intervention, students' attitudes varied widely regarding its various aspects. Thus, although the majority had positive attitudes toward its importance and related concerns, only a minority had such attitudes regarding their personal vulnerability and their roles. This would certainly have a negative impact on their preparedness to deal with the problem by changing their personal behaviors. In congruence with this present study result, a study in Finland addressing nurses' perceptions of the health impacts of climate change revealed a lack of positive attitudes due to deficient necessary knowledge to support and participate in climate change and sustainability development strategies **(Tiitta et al., 2021)**.

In the post-intervention phase, students' attitudes statistically improved in all aspects, with the majority having positive total attitudes. These improvements were maintained through the follow-up phase. This could be attributed to an indirect effect of the intervention program as shown by the results of the multivariate analysis, where the knowledge score was the main independent positive predictor of the knowledge score. Thus, the improvements in students' knowledge accomplished by the intervention led to improvements in their attitudes. Moreover, a strong positive correlation was revealed between students' knowledge and attitudes scores. A similar strong positive correlation was reported between students' knowledge and attitudes scores in a study in Egypt **(Ibrahim, Mohammed and Samir, 2022).**

The multivariate analysis has also demonstrated that a higher income positively predicted the score of students' attitudes. The finding is quite plausible since a higher socioeconomic level is known to have a positive impact on individuals' health-related attitudes and behaviors. In congruence with this, a study of the attitudes and behaviors related to the adoption of plant-based diets in Greece, India,

and the United Kingdom revealed that the students having more satisfactory knowledge and practicing physical activity were more willing to switch to plant-based diets as one of the positive practices related to climate change **(Raptou et al., 2024)**.

Lastly, the present study involved university students' practices related to climate change. The results demonstrated that these students' pre-intervention practices were much better when compared with their knowledge and attitudes. Thus, slightly less than two-thirds of them had total adequate practice. This could be because they were asked about their practices, i.e., reported rather than observed practices, which would be associated with the tendency to embellish one's responses in self-reporting to improve self-image. In this respect, **Matlack et al. (2023)** pointed to the lack of a standardized tool to assess climate change literacy, including behaviors and practices, and thus attempted to develop such an instrument. Meanwhile, a recent systematic review addressed the effect of this self-reporting bias **(Vasireddi et al., 2024)**.

The application of the current study intervention phase led to significant improvements in students' reported practices. However, only the practices related to the use of environment-friendly things did not demonstrate significant improvements. This might be explained by the difficulty in applying such practices given the difficulty in obtaining such things and their rarity. This is supported by the finding that such practices related to the use of environment-friendly things significantly improved at the follow-up phase. Again, the positive impact of the intervention on students' behaviors was achieved through an indirect effect of the study intervention by improving students' knowledge and attitudes as these were identified as the main positive predictors of the practice score. Additionally, significant positive correlations were shown between the practice scores and each of the scores of knowledge and attitudes.

In agreement with the foregoing, a recent study in the United States reported a significant improvement in university students' intentions to practice sustainable behaviors related to climate change following an educational campaign **(Varni et al., 2024)**. In the same vein, a study of

Australian university students' perceptions of sustainable food demonstrated that those students who had sound knowledge were more willing to adopt practices that would enhance sustainability and environmental benefits **(Lopes et al., 2024)**.

Other factors that seem to have a positive influence on the post-intervention changes in university students' scores of practice were having an urban residence, sufficient family income, and practicing physical exercise. The finding is fairly reasonable since some of the practices could be more costly, for example, the practice of using environment-friendly things. They might also not be available to those residing in rural areas. In line with this, a study in India examining the relationship between the awareness of climate change and various socioeconomic factors demonstrated that higher classes had significantly better knowledge and behaviors **(Vishwakarma et al., 2023)**. On the same line, a study of climate change knowledge and attitudes among the general population in Ismailia found a significant association with the place of residence **(Hussein and Ibrahim, 2024)**.

Conclusion

The educational program is effective in improving university students' knowledge, attitude, and reported practices regarding climate change. The main study limitation is the potential self-reporting bias in assessing students' practices, yet the alternative of assessment by observation is logistically impossible.

Recommendations

Considerable work is required to integrate climate change concepts into the university curricula irrespective of their academic study specialization. The developed program and booklet could serve as a basis for further educational interventions.

Acknowledgement

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