REVIEW ARTICLE

Egyptian Perception, Awareness, and Knowledge of Nanotechnology: A Study Based on an Egyptian University Approach

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ABSTRACT

Scientific literacy as a goal of a science education reform remains a critical discourse in the research literature. It is crucial to students' understanding and acceptance of emergent technologies like Nanotechnology (NT). Due to informational input from physicists, chemists, engineers, geologists, and biologists, NT is a vibrant field of science today. Despite the extensive use of Nanomaterials (NMs) in daily life, little is known by the general public regarding the capabilities, advantages, and potential risks of NT. Like with any emerging technology, its public perception has direct implications on future policies and has to be taken into considerations by both academia and industry. An online survey of sociodemographic graduates was conducted as part of the interdisciplinary awareness initiative at Cairo University. The survey was prepared based on previous studies and introduced to the staff, graduates, and students sample of Cairo University (343 votes), selected from different faculties in different stages, were considered. The resulting data were analyzed using SPSS technical analysis method. The main goal was to evaluate the current levels of knowledge and the attitude toward NT among the general Egyptian public and to determine how the differing sociodemographic factors (e.g., in terms of age, sex, and educational background) may affect it. This paper summarizes the findings of a study of public attitudes toward NT, highlighting both concerns and aspirations for NT, and discusses the impacts of that data on public engagement programs. We found that while Egyptians display a generally optimistic view and a positive attitude toward NT, there are concerns about its safety and possible risks. Participants expressed a great desire for more information about its applications and clear labeling and transparency of products containing NMs. Notably, we found that participants with a university degree were generally more knowledgeable on this topic; surprisingly, there were no significant differences in the attitude toward NT among people from different educational backgrounds. This shows the difficulty in mitigating public aversion solely by providing more information on the subject; depending on who you talk to, the perception of what the public thinks about NT can vary.

Key Words: *Nanotechnology in Old Egypt; Public Perception; Awareness and Knowledge Of Nanotechnology; Risks; Benefits*

INTRODUCTION

How old is nanotechnology?

Large-scale emotional engineering achievements of the ancient world are remembered, including the Parthenon in Greece, the pyramids in Egypt, and Macchu Picchu in Peru, to name a few. In addition, the crafters were adept in engineering at the opposite end of the nanoscale.

About 11 billion–15 billion years ago, moment, matter, energy, space, and time didn't exist; all were concentrated into an area the size of an atom. Suddenly, the universe began to expand at a fantastic rate, and matter, energy, space, and the time came into being (the Big Bang). Hence, concern began to combine into gas clouds and stars and planets. Now, the universe continues to expand along with the existence of these nanoparticles.

Prehistoric events date back to the time before the invention of writing—roughly years ago. Scientists studying the lives of prehistoric people encounter unique challenges since they lack access to written records. Due to man-made activities like wars and natural disasters such as earthquakes, tsunamis, floods, volcanic eruptions, and meteor showers, which have caused tremendous adverse effects, much knowledge has been lost. However, historical texts from Spain, Italy, and the Middle East have revealed how lusterware was made and offered a new procedure for generating metal-glass nanocomposites.

In the prehistoric period, information or knowledge was passed from generation to generation by word of mouth and was not written down, otherwise known as "oral tradition." After the invention of writing—roughly 5,000 years ago—gathered knowledge was recorded in written form on rocks, bhojpatra (thin stripes/sheets of the processed bark of the Himalayan birch tree), and later on papyrus (tadpatra). Writing development enabled knowledge to be stored and passed across generations with much greater reliability. Early civilizations were made feasible by the advancement of agricultural techniques, which produced more food and freed up time for activities other than ensuring one's existence, like seeking knowledge for its own reason [1].

Nanotechnology in ancient Egypt

Archaeological remains that covered the majority of Egypt's land and were widely dispersed throughout Egyptian museums and the rest of the world are proof that the Egyptian civilization excelled in various fields. It has excelled Egyptian civilization in architecture, arts and literature, science and faith, and left a clear imprint on some contemporary civilizations. The discoveries of the Egyptians in science, chemistry, medicine, astronomy, sports, and they were pioneers preceded others in the knowledge of writing a hieroglyphic are perhaps the next and most important evidence of creativity. Furthermore, engineering whose supremacy can still be seen today in the majestic architecture of the Pyramids and Karnack. Seven millennia ago, an ingenious technique for measuring time was invented to clock the periods of the Nile flooding; this methodology led to the birth of the solar calendar. Chemistry as a field has its root in the name of the ancient land, and the art of the discipline was in full use there for making glass, bronze, and metal chemistry. Even the synthesis of new compounds was known at the time. According to a recent report by a team of French scientists, the eye cosmetics used at the time of Nefertiti contained a man-made lead compound that helped treat or prevent eye disease [2].

The creativity of the ancient Egyptians did not stop at astronomy, medicine, architecture, and others. The ancient Egyptians were eager to decorate their religious buildings, including temples and tombs, in order to prepare for the afterlife, thus, it expanded beyond just funerary furniture and other cemetery

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holdings of artifacts and tools to include manufacturing technology for various materials. Gold has been enhanced with gems and other treasures. Ancient Egyptians were interested in using natural ores found in the area to decorate the walls of their temples and tombs because they were stable and resistant to the effects of time and change.

The ancient Egyptian then turned to making another substance that he utilized for coloring in blue when he realized that some resources, such copper ores from azurite and malachite, were not readily available or were unstable. The result was his creation of "Egyptian Blue," the earliest intentionally manufactured significance in history. The Egyptian blue color was a technological breakthrough in ancient Egypt and began to be used from the era of the Old Kingdom "Fourth Dynasty 2575 BC–2467 BC." Up to the Roman era, this material for coloring blue was continuously used, and that technology was transmitted to other civilizations like the Greek and Roman civilizations. This material is a silicate of copper and calcium or cap orifice ($CaCuSi_4O_{10}$) and was prepared by heating a group of basic materials needed to make the color, including copper ores or some copper alloys such as bronze, especially in the era of the modern state, in addition to an abundant amount of sand next to limestone powder and a small percentage of salt Natron, which was mixed in the form of balls and heated at temperatures ranging from 800°C to 1,000°C, the final product has a distinctive bright blue color and crystalline grains of varying sizes with a significantly high degree of stability.

A research team from the University of Georgia was taken aback by recent studies on this substance, including work that was recently published in the Journal of the American Chemical Society. This is in addition to the significance of color in ancient Egypt and its use in coloring and decorating tombs, temples, and other artifacts and tools as well as the splendor of its manufacturing technology that was associated with Egypt. According to the American University, the thickness of Egyptian blue crystals is not greater than that of precise nanoslices (1,000 times the thickness of a human hair).

Egyptian blue has been known to have unique properties and natures since 2009, and Dr. Gianluca Accorsi, a researcher in nanosciences at the Italian National Research Center CNR has confirmed this in his research. He discovered that Egyptian blue emits near-infrared rays (NIF) when exposed to visible light.

What the British Museum has already used to identify the color remnants of marble carvings from the Greek Parthenon Temple. This characteristic can be seen in Egyptian blue, according to the British Museum Bulletin. The solid infrared rays that it emits when exposed to visible light make it possible to distinguish between the grains of the same substance even at a few meters away.

However, this can have many applications in different fields, because the rays generated are "near-infrared rays" which penetrate objects more than other waves, and therefore can have many applications, especially in the means of communication and remote control, whether Television, cars, inkjet printers, etc., as well as generating rather high-cost laser beams, as well as medical applications in X-ray examination devices for human tissues.

Researchers from Curtin University in Australia conducted a study in which they crushed an Egyptian blue material into fine powder and exposed it to light. They discovered that this feature is helpful to investigators in identifying fingerprints, particularly on bright surfaces. The produced rays were recorded by sensitive cameras.

Egyptian blue's constituent parts are inexpensive since we must prepare it. The availability of ores of copper, limestone, and alkaline magma materials is abundant in Egypt. This gives Egyptian blue another advantage when generating near-infrared radiation at a low economic cost and using it in many industrial and medical fields.

Accordingly, the ancient Egyptian succeeded in dazzling the world, ancient and modern, with their genius and the product of their experiences and expertise in a way that the eyes of the world can witness from the drawings of tombs and the splendor of archaeological holdings that abound in most of the world's museums, as well as in various industrial and medical applications of materials invented by the ancient Egyptian for the first time in thousands of years.

LITERATURE ON THE PUBLIC PERCEPTIONS OF NANOTECHNOLOGY

The world today stands at the threshold of rapid scientific advancement, the event of scientific discoveries, which is the science of Nanotechnology (NT). This technology is viewed by some as the revolution of the twenty-first century that will cause a broad change in how many countries view it. The research and development in nanotechnology will alter many traditional practices in the design and production of electronic goods, information technology, computers, biotechnology in energy, and other spheres of life. The interest in NT at present and future stages is primarily due to its low-cost modern technology compared to other technologies and its high economic returns. They integrate science and technology, starting from the essential components of matter (atoms and molecules) to move toward scientific applications so that this technique will cover all areas of science. Researchers have been inspired to participate in its applications in a variety of contexts as a result of the enormous advancements made in NT. These advancements have impacted people's needs in a variety of ways, including the medical field, the energy sector, the management of pollution, and the food industry.

Based on the preceding, NT is one of the most important technologies today and in the future. It has become one of the most critical areas, and this technology is promising a massive leap in all areas of science. Having considered the importance of improving products, producing environmentally friendly waste and, maintaining energy production against renewable energy systems, improving pharmacological properties, thus ensuring that we are aware of the distinct properties of Nanomaterials (NMs) in creating innovations that benefit humanity, and to harness it for the benefit of the human being in meeting all his needs, thus saving him much time, effort and less cost.

NT has raised many issues, such as health, environmental, social, and educational, as pointed out by Ramazan[3].

Few studies have been done to understand nanotechnology's general perception and interest. Most studies have focused on risk concerns. The Harthorn group also analyzed 22 NT risk perceptions, showing that people aware of the benefits outnumber those who see the risks. Currall et al. analyzed several responses to understand whether risks or benefits were the driving force in the selection of NT products [4]. It was confirmed that non-experts were more concerned with the dangers of NT than the scientific communities. Pidgeon conducted the first public participation experiment in NT; participants were also found to have focused on benefits rather than risks while having a high value for science and technology[5]. Other studies have concerned themselves with particular population characteristics such as cultural perception and religious beliefs. These studies thus shed light on the public's perception of NT.

Many studies have noted that the public lacks knowledge of NT and is unfamiliar with its basic concepts and principles [6-12]. Although there are some national variations, studies in several countries confirm this result. One of the first studies of public attitudes toward NT found that the public had a high level of enthusiasm for the benefits of NT and little concern over risks, and later studies have confirmed this result, demonstrating that nanotechnology is perceived by the public as beneficial and not associated with risk [13-15]. Other studies have found that many people are indifferent to NT. Another often noted seeing is that the public is not homogeneous but consists of many groups and segments with different outlooks, values, and approaches to new technology [16,17].

NT is generally not an issue that spurs public engagement, and only a minority of citizens take an active interest in nanotechnology and how it should be governed in society [18]. When they are concerned, members of the public are worried about the societal implications of nanotechnology use, its environmental effects [19], and whether its benefits will be pretty distributed [20].

Current research on public perceptions of nanotechnology

NT is the 21^{st}-century technological revolution in many research areas due to its remarkable structural, morphological, and magnetic properties. It is considered the synthesis, characterization, and exploration of materials in the nanometer region (1 nm–100 nm). This property allows their possible applications in many fields such as biosensors, food packaging, nanomedicine, and bionanotechnology [21]. Therefore, some countries' government bodies responsible for science and economic development have devoted significant resources to basic and applied research in nanotechnology. There are several surveys about the extent to which individuals know about NT.

Furthermore, it has been discovered that the decrease in media coverage of topics related to NT has led to the public's lack of knowledge about NT. It has been found that more people see the benefits of NT more than its risks [22]. Nevertheless, in one of the early surveys, which focused on health benefits only or health risks, and so on, it was discovered that the concept of NT differs among the public [23]. Random sample surveys based on trust in business leaders and scientists have been an essential predictor of views on nanotechnology. However, it has been discovered that religious views affect emerging surveys about the use of NT in the medical field, such as those related to stem cell research [24,25], and also affect the rest of science and the development of food [26,27]. Surveys of scientists have shown that scientists are more interested in the benefits of nanotechnology in health and the environment than the public [28].

We conclude that surveys and future studies have an essential impact on opinions, perceptions, and public knowledge.

Nanotechnology in Egypt

The industrialized nations have long recognized the social and economic potentials of nanotechnology and promptly responded to its emergence by devoting a significant amount of resources to advancing it and ultimately benefiting from it. On the other hand, until recently, the developing nations particularly the Arab nations, were reluctant to respond to the development of nanotechnology. The interest in nanotechnology, among the other promising technologies, is related to the new phase of political reform and economic development in these countries. A growing number of nanotechnology research, education, and industry initiatives have been recently launched by several Arab countries to quickly build scientific capacity and follow the global developments in nanotechnology with an emphasis on Science and Technology (S&T) for promoting sustainable development. Egypt does not have a formally enacted national science policy. However, the number of well-established scientific institutions indicates an implicit national policy. The S&T development started in Egypt in the late 1940s. Egypt had a National Research Center, the Higher Council for Science, and intellectual property law by the 1950s. The Academy of Scientific Research and Technology (ASRT) was created in 1972 after the Ministry of Scientific Research was established in 1963. ASRT's role is to devise a comprehensive plan for developing S&T to support the relevant national ministries and research institutions. ASRT's mission is to create an integrated system of scientific research to increase the number of trained scientists in Egypt and give science a leading role in the country's development and knowledge-based economy. In 2008, the Higher Council for Science and Technology (HCST) was established. The council is chaired by the Prime Minister and includes the minister of higher education, scientific research, and a group of prominent Egyptian scientists. HCST was created to promote R&D in the country and identify the priority research areas, which include health, water resources, renewable energy, food and agriculture, and space technology. HCST selected nanotechnology as one of the priority research areas in the coming years. As a result, the Science and Technology Development Fund (STDF) and the Information Technology Industry Development Agency (ITIDA), the two leading funding agencies in Egypt, supported several initiatives to introduce nanotechnology to the Egyptian scientific community in the past few years. In particular, STDF has prioritized funding grants targeting NT and its applications.

Beginning in 2003, initiatives to create micro/nano fabrication and research facilities were made. This is marked by the establishment of the Yousef Jameel Science and Technology Research Center (YJ-STRC) at the American University in Cairo (AUC). YJ-STRC was the fruit of the generous support ($8 million over five years) of a Saudi businessman and AUC alumnus Yousef Jameel. His vision was to create a NT center of excellence at AUC. The center houses class-100 clean rooms and state-of-the-art fabrication and characterization equipment. It should be noted that AUC offers a Master of Science degree in NT and a Doctor of Philosophy degree in the Applied Sciences with specializations in NT. To date, YJ-STRC has secured $13 million in funding and recruited 17 high-profile faculty members with diverse backgrounds. YJ-STRC carried out its work through six research groups: micro-and nano-systems, nanostructured materials, surface chemistry, biotechnology, environmental science and engineering, and novel diagnostics and therapeutics. The research groups are serviced by well-equipped research facilities, such as micro-and nano-systems fabrication, materials synthesis, biotechnology, and surface chemistry.

In 2006, the Nile University (NU) was established, through the support of the international and national companies represented by the Egyptian Foundation for Technological Education Development (EFTED), as a nonprofit, privately owned, and autonomously managed university. The NU is the first academic institution in Egypt to be founded by a partnership between the private sector (EFTED), government, business, and industry. NU was allocated approximately 0.5 km2 of land and two buildings by the government. NU offers a Master of Science in Nanoscience and Technology degree. NU also houses two NT centers. The Center for Nanotechnology (CNT) was established based on collaboration with the Northwestern University in the United States. CNT researchers work on printed electronics, membrane technology, and renewable energy. The other center is the Nanoelectronics Integrated Systems Center (NISC), which Intel funded, Mentor Graphics, British Petroleum, European Union, Cypress Semiconductor Corp, ITIDA, STDF, and the National Telecom Regulatory Authority. NISC is pursuing research in high-performance Integrated Circuits (ICs), computer-aided design ICs, low-power circuit design, hardware for wireless sensor networks, and nanotechnology was designated as a priority research field by the Zewail City of Science and Technology, which was established in 2011. Center of Nanoelectronics and Devices (CND) one of the city's seven startup centers, is currently building its research team from among the world-renowned Egyptian scientists returning to post-revolution Egypt. CND will focus on high-performance ICs, MEMS, and Lab-on-chip research. Furthermore, Zewail University, an integrated part of Zewail City, offers majors in nanotechnology engineering and nanoscience to undergraduate students.

In an attempt to capture the currently underutilized human potential in Egypt, IBM teamed up with ITIDA and STDF to create Egypt's first nanotechnology national research laboratory in 2008, the Egypt-IBM Nanotechnology Research Center (EGNC). The center is said to be operational by 2014. The idea was to have IBM experts work with the local scientists and engineers on advanced nanoscience and nanotechnology projects. With a $60 million investment, EGNC will include a 600 m^2 clean room and 28 laboratories specializing in nanotechnology. The startup workforce of the EGNC was about 100 research and administrative staff but is expected to grow to 1,000 within the next few years. Current research areas at EGNC include thin-film silicon photovoltaics, spin-on carbon-based electrodes for thin-film photovoltaics, energy recovery from concentrator photovoltaics for desalination, and computational modeling and simulation.

METHODOLOGY AND RESEARCH QUESTIONS

Awareness of nanotechnology as a concept

- Has the public had an awareness of the application of nanotechnology used in the field of medicine?
- The knowledge's scale of how ethics manipulate with nanotechnology?
- Effect of Sociodemographic variables on nanotechnology understanding.
- How do college students view the solutions that should offer to facilitate the communication of nanotechnology to the public?
- The opinions of college students regarding the application of nanotechnology used in the field of medicine
- What is the relationship between the constructions of problems and solutions concerning the communication of nanotechnology to the public?

STATISTICAL ANALYSIS

Respondent's characteristics

The following Table 1 and Figure 1 show the distribution of gender of participants, the most participants 259 (75.51%) were male, and 84 (24.49%) were female.

Table 2 shows that most of the participants, 258 (75.22%) aged between 21 and 40 years, followed by 51 (14.87%) between 41 and 60 years, 18 (5.25%) less than 20 years, and 16 (4.66%) older than 60 years.

As shown in Table 3, most of the participants, 188 (54.81%), have BSc, 95 (27.70%) have Ph.D., 52 (15.16%) have Master's, and only 8 (2.33%) have secondary school.

As shown in Table 4, 115 (33.53%) participants are governmental employees, 107 (31.20%) are students, 77 (22.45%) work in the private sector, and 35 (10.20%) are retired-unemployment, and only 9 (2.62%) are housewife.

TABLE 1
Gender of the participants

Gender	Frequency	Percentage
Female	259	75.51
Male	84	24.49
Total	343	100

Egyptians' awareness of nanotechnology

As shown in Table 5, most of the participants, 313 (91.25%), know about nanotechnology, 26 (7.58%) participants are not sure about their knowledge, and only 4 (1.17%) do not know about nanotechnology.

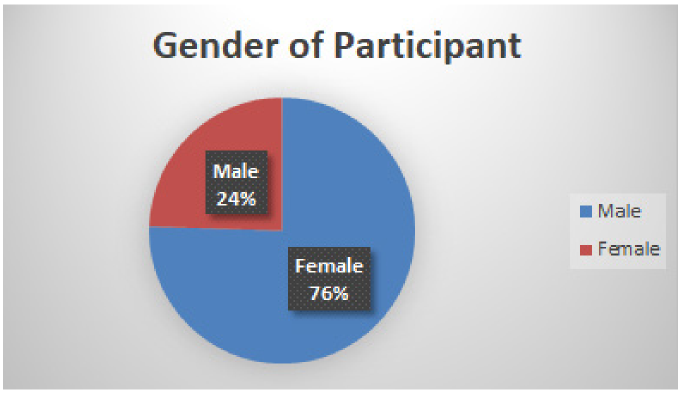

Figure 1) *Distribution of gender of participants*

TABLE 2
Age of the participants

Age group	Frequency	Percentage
Less than 20 years	18	5.25
21 years–40 years	258	75.22
41 years–60 years	51	14.87
Older than 60 years	16	4.66

TABLE 3
Educational level of the participants

Educational level	Frequency	Percentage
BSc	188	54.81
Master	52	15.16
PhD	95	27.7
Secondary school	8	2.33
Total	343	100

TABLE 4
Employment of participants

Employment	Frequency	Percentage
Governmental	115	33.53
Housewife	9	2.62
Private sector	77	22.45
Retired-Unemployed	35	10.2
Student	107	31.2
Total	343	100%

TABLE 5
Knowledge of "nanotech" in participants

Do you know what "Nanotech" is?	Count	Percent
No	4	1.17
Not sure	26	7.58
Yes	313	91.25
Total	343	100

Awareness of nanotechnology according to gender

Cramer's value (0.000265) indicates a small (or "weak") association between gender and awareness of nanotechnology as shown in Table 6.

Awareness of nanotechnology according to education

Cramer's value (0.01) indicates a small (or "weak") association between Education level and awareness of nanotechnology. Also, we can see that most BSC participants know the definition as shown in Table 7.

Awareness of nanotechnology according to employment

Cramer's value (0.0241612) indicates a small (or "weak") association between employment and awareness of nanotechnology, and the vast percent of awareness was for the Governmental participants as shown in Table 8.

Awareness of nanotechnology according to age

We can notice here that the most sample was for the participants 21 years–40 years old, and they know what "Nanotech" is; according to Cramer's value (0.0044037) indicates a small (or "weak") association between age and awareness of nanotechnology as shown in Table 9.

Egyptians' attitude toward nanotechnology

Exposition to nanotechnology according to gender (Table 10)

TABLE 6
Awareness of nanotechnology according to gender

Do you know what "Nanotech" is?		Female	Male	All
No	N	3	1	4
	%	1.16	1.19	1.17
Not sure	N	19	7	26
	%	7.34	8.33	7.58
Yes	N	237	76	313
	%	91.51	90.48	91.25
Total	N	259	84	343
	%	100	100	100
Correlation (Cramer's V-square)	0.000266			

TABLE 7
Awareness of nanotechnology according to education

Do you know what "Nanotech" is		BSc	Master	PhD	Secondary school	All
No	N	3	0	1	0	4
	%	1.6	0	1.05	0	1.17
Not sure	N	20	1	4	1	26
	%	10.64	1.92	4.21	12.5	7.58
Yes	N	165	51	90	7	313
	%	87.77	98.08	94.74	87.5	91.25
Total	N	188	52	95	8	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0					

TABLE 8
Awareness of nanotechnology according to employment

Do you know what "Nanotech" is?		Governmental	Housewife	Private sector	Retired-unemployed	Student	All
No	N	1	1	0	0	2	4
	%	0.87	11.11	0	0	1.87	1.17
Not sure	N	5	2	6	5	8	26
	%	4.35	22.22	7.79	14.29	7.48	7.58
Yes	N	109	6	71	30	97	313
	%	94.78	66.67	92.21	85.71	90.65	91.25
Total	N	115V	9	77	35	107	343
	%	100	100	100	100	100	100
Correlation (Cramer's V-square)	0.024161						

TABLE 9
Awareness of nanotechnology according to age

Do you know what "Nanotech" is		21–40 years	41–60 years	Less than 20 years	Older than 60 years	All
No	N	3	1	0	0	4
	%	1.16	1.96	0	0	1.17
Not sure	N	19	3	3	1	26
	%	7.36	5.88	16.67	6.25	7.58
Yes	N	236	47	15	15	313
	%	91.47	92.16	83.33	93.75	91.25
Total	N	258	51	18	16	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.004404					

TABLE 10
Exposition to nanotechnology according to gender

Are you exposed to "Nanotech"		Female	Male	All
Moderate	N	97	31	128
	%	37.45	36.9	37.32
Rare	N	114	39	153
	%	44.02	46.43	44.61
Very common	N	48	14	62
	%	18.53	16.67	18.08
Total	N	259	84	343
	%	100	100	100
Correlation (Cramer's V-square)	0.000613			

TABLE 11
Exposition to nanotechnology according to education

Are you exposed to "Nanotech"		BSc	Master	PhD	Secondary school	All
Moderate	N	61	21	43	3	128
	%	32.45	40.38	45.26	37.5	37.32
Rare	N	108	18	23	4	153
	%	57.45	34.62	24.21	50	44.61
Very common	N	19	13	29	1	62
	%	10.11	25	30.53	12.5	18.08
Total	N	188	52	95	8	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.05281					

TABLE 12
Exposition to nanotechnology according to employment

Are you exposed to "Nanotech"		Governmental	Housewife	Private sector	Retired-unemployed	Student	All
Moderate	N	46	3	26	10	43	128
	%	40	33.33	33.77	28.57	40.19	37.32
Rare	N	36	5	42	20	50	153
	%	31.3	55.56	54.55	57.14	46.73	44.61
Very common	N	33	1	9	5	14	62
	%	28.7	11.11	11.69	14.29	13.08	18.08
Total	N	115	9	77	35	107	343
	%	100	100	100	100	100	100
Correlation (Cramer's V-square)	0.029492						

Exposition to nanotechnology according to education. (Table 11)

Exposition to nanotechnology according to employment (Table 12)

Exposition to nanotechnology according to age (Table 13)

Egyptians' opinion on the positive effects of nanotechnology on human health (Table 14)

Egyptians' opinion on the positive effects of nanotechnology on human health by gender (Table 15)

Egyptians' opinion on the positive effects of nanotechnology on human health through education (Table 16).

Egyptians' opinion on the positive effects of nanotechnology on human health by employment (Table 17)

Egyptians' opinion on the positive effects of nanotechnology on human health by age Table (18)

Egyptians' opinion on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched

TABLE 13
Exposition to nanotechnology according to age

Are you exposed to "Nanotech"		21 years-40 years	41 years–60 years	Less than 20 years	Older than 60 years	All
Moderate	N	92	25	6	5	128
	%	35.66	49.02	33.33	31.25	37.32
Rare	N	128	12	7	6	153
	%	49.61	23.53	38.89	37.5	44.61
Very common	N	38	14	5	5	62
	%	14.73	27.45	27.78	31.25	18.08
Total	N	258	51	18	16	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.022872					

TABLE 14
Egyptians' opinion on the positive effects of nanotechnology on human health

Is nanotechnology has positive effects on human health?	Count	Percent(%)
Agree to some extent	188	54.81
Disagree	10	2.92
Totally agree	145	42.27
Total	343	100

TABLE 15
Egyptians' opinion on the positive effects of nanotechnology on human health by gender

Is nanotechnology having positive effects on human health?		Female	Male	All
Agree to some extent	N	146	42	188
	%	56.37	50	54.81
Disagree	N	7	3	10
	%	2.7	3.57	2.92
Totally agree	N	106	39	145
	%	40.93	46.43	42.27
Total	N	259	84	343
	%	100	100	100
Correlation (Cramer's V-square)	0.003172			

Table 16
Egyptians' opinion on the positive effects of nanotechnology on human health through education

Is nanotechnology having positive effects on human health?		BSc	Master	PhD	Secondary school	All
Agree to some extent	N	95	27	62	4	188
	%	50.53	51.92	65.26	50	54.81
Disagree	N	3	3	3	1	10
	%	1.6	5.8	3.2	12.5	2.92
Totally agree	N	90	22	30	3	145
	%	47.9	42.3	31.6	37.5	42.27
Total	N	188	52	95	8	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.017139					

TABLE 17
Egyptians' opinion on the positive effects of nanotechnology on human health by employment

Is nanotechnology having positive effects on human health?		Governmental	House wife	Private sector	Retired-unemployed	Student	All
Agree to some extent	N	71	3	44	18	52	188
	%	61.7	33.3	57.1	51.4	48.6	54.81
Disagree	N	3	0	2	1	4	10
	%	2.6	0	2.6	2.9	3.7	2.92
Totally agree	N	41	6	31	16	51	145
	%	35.7	66.7	40.3	45.7	47.7	42.27
Total	N	115	9	77	35	107	343
	%	100	100	100	100	100	100
Correlation (Cramer's V-square)	0.009635						

yet (Table 19)

Egyptians' opinion (by gender) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet (Table 20)

TABLE 18
Egyptian's opinion on positive effects of nanotechnology on human health by age

Is Nanotechnology has positive effects of human health?		21 years–40 years	41 years–60 years	Less than 20 years	Older than 60 years	All
Agree to some extent	N	131	38	9	10	188
	%	50.8	74.5	50	62.5	54.81
Disagree	N	7	1	1	1	10
	%	2.7	2	5.6	6.3	2.92
Totally agree	N	120	12	8	5	145
	%	46.5	23.5	44.4	31.3	42.27
Total	N	258	51	18	16	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)		0.017022				

TABLE 19
Egyptians' opinion on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet

Nanotechnology is already used, even though the implications?	Count	Percent
Agree	135	39.36
Agree to some extent	170	49.56
Disagree	38	11.08
Total	343	100

TABLE 20
Egyptians' opinion (by gender) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet

Nanotechnology is already used, even though the repercussions?		Female	Male	All
Agree	N	101	34	135
	%	39	40.5	39.4
Agree to some extent	N	129	41	170
	%	49.8	48.8	49.6
Disagree	N	29	9	38
	%	11.2	10.7	11.1
Total	N	259	84	343
	%	100	100	100
Correlation (Cramer's V-square)	0.000179			

TABLE 21
Egyptians' opinion (by education) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet

Nanotechnology is already used, even though the repercussions?		BSc	Master	PhD	Secondary school	All
Agree	N	66	20	44	5	135
	%	35.1	38.5	46.3	62.5	39.4
Agree to some extent	N	95	26	46	3	170
	%	50.5	50	48.4	37.5	49.6
Disagree	N	27	6	5	0	38
	%	14.4	11.5	5.3	0	11.1
Total	N	188	52	95	8	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.013198					

TABLE 22
Egyptians' opinion (by employment) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet

Nanotechnology is already used, even though the repercussions?		Governmental	Housewife	Private sector	Retired-Unemployed	Student	All
Agree	N	51	3	36	8	37	135
	%	44.3	33.3	46.8	22.9	34.6	39.4
Agree to some extent	N	55	2	31	21	61	170
	%	47.8	22.2	40.3	60	57	49.6
Disagree	N	9	4	10	6	9	38
	%	7.8	44.4	13	17.1	8.4	11.1
Total	N	115	9	77	35	107	343
	%	100	100	100	100	100	100
Correlation (Cramer's V-square)	0.031931						

Egyptians' opinion (by education) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet (Table 21)

Egyptians' opinion (by employment) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet (Table 22)

Egyptians' opinion (by age) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet (Table 23)

Products containing nanomaterials are precise and transparent?

According to Table 24, 150 (43.7%) disagree with the fact that products containing nanomaterials are clear and transparent, while 147 (42.9%) agree to some extent and 46 (13.4%) agree.

TABLE 23
Egyptians' opinion (by age) on nanotechnology is already used, even though the repercussions on health and the environment are not sufficiently researched yet

Nanotechnology is already used, even though the repercussions?		21 years–40 years	41 years –60 years	Less than 20 years	Older than 60 years	All
Agree	N	95	24	9	7	135
	%	36.8	47.1	50	43.8	39.4
Agree to some extent	N	129	25	7	9	170
	%	50	49	38.9	56.3	49.6
Disagree	N	34	2	2	0	38
	%	13.2	3.9	11.1	0	11.1
Total	N	258	51	18	16	343
	%	100	100	100	100	100
Correlation (Cramer's V-square)	0.010955					

TABLE 24
Products containing nanomaterials are precise and transparent?

Are Products containing nanomaterials clearly and transparently?	Count	Percent(%)
Agree	46	13.4
Agree to some extent	147	42.9
Disagree	150	43.7
Total	343	100

TABLE 25
Products containing nanomaterials are precise and transparent? (Gender)

Are products containing nanomaterials clearly and transparently?		Female	Male	All
Agree	N	28	18	46
	%	10.8	21.4	13.4
Agree to some extent	N	115	32	147
	%	44.4	38.1	42.9
Disagree	N	116	34	150
	%	44.8	40.5	43.7
Totally	N	259	84	343
	%	100	100	100

TABLE 26
Products containing nanomaterials are precise and transparent? (Age)

Are products containing nanomaterials clearly and transparently?		21 years–40 years	41 years–60 years	Less than 20 years	Older than 60 years	All
Agree	N	35	5	3	3	46
	%	13.6	9.8	16.7	18.8	13.4
Agree to some extent	N	115	20	5	7	147
	%	44.6	39.2	27.8	43.8	42.9
Disagree	N	108	26	10	6	150
	%	41.9	51	55.6	37.5	43.7
Total	N	258	51	18	16	343
	%	100	100	100	100	100

TABLE 27
Products containing nanomaterials are precise and transparent? (Education)

Are products containing nanomaterials are clearly and transparently?		BSc	Master	PhD	Secondary school	All
Agree	N	25	8	12	1	46
	%	13.3	15.4	12.6	12.5	13.4
Agree to some extent	N	84	22	38	3	147
	%	44.7	42.3	40	37.5	42.9
Disagree	N	79	22	45	4	150
	%	42	42.3	47.4	50	43.7
Total	N	188	52	95	8	343
	%	100	100	100	100	100

TABLE 28
Products containing nanomaterials are precise and transparent? (Employment)

Are products containing nanomaterials are clearly and transparently?		Governmental	Housewife	Private sector	Retired-unemployed	Student	All
Agree	N	14	0	8	7	17	46
	%	12.2	0	10.4	20	15.9	13.4
Agree to some extent	N	44	5	36	14	48	147
	%	38.3	55.6	46.8	40	44.9	42.9
Disagree	N	57	4	33	14	42	150
	%	49.6	44.4	42.9	40	39.3	43.7
Total	N	115	9	77	35	107	343
	%	100	100	100	100	100	100

According to Table 25, 116 (44.8%) of females disagreed, 116 (44.8%) agreed to some extent, and 28 (10.8%) agreed. For males, 150 (43.7%) disagreed, 147 (42.9%) agreed to some extent, and 46 (13.4%) agreed.

Table 26 showing acceptance of products containing nanomaterials are precise and transparent according to age.

Table 27 showing acceptance of products containing nanomaterials are precise and transparent according to education.

Table 28 showing acceptance of products containing nanomaterials are precise and transparent according to Employment.

CONCLUSION

Consumer awareness of the usefulness, benefits and potential risks of Nanotechnology (NT) is still limited, despite the growing use of Nanomaterials (NMs) in everyday life. As with any emerging technology, public opinion directly impacts future policy and must be considered by both academia and industry. An online poll was done to assess current levels of awareness and attitudes concerning NT among the Egyptian academic public and the impact of various sociodemographic characteristics. A total of 343 replies were collected and quantitatively analyzed over three months. Although Egyptians have a generally optimistic perspective of NT and a good attitude toward it, we discovered that there are still questions regarding its safety and potential risk. More information regarding NT and its applications, as well as clear labeling and transparency of items containing NMs, were requested by participants. Notably, we discovered that neither the general attitude toward NT nor the degrees of NT awareness were affected by age. Even though participants with a university degree were generally more aware of this topic, there were no significant variations in attitudes toward NT among those with various educational levels. We found that female participants had a more positive attitude toward NT and scored marginally higher in our NT questionnaire than male anticipants, similar to earlier studies. Also, female participants, on the other hand, expressed a stronger desire for more knowledge and transparency about NMs. Surprisingly, those with a negative attitude about NT scored the lowest on the NT quiz; they also showed the least interest in learning more about NT. This shows the challenge of just providing more information to alleviate public antipathy.

NT is a broad and complicated concept that describes a world we can't see and its myriad applications that arise from manipulating atoms and molecules. Improving awareness of emerging technology is critical to facilitating social and educational debates and minimizing public reaction. Although Egyptians are largely positive about NT, there are still concerns about its safety and potential risks, particularly regarding NT use in nutritional and cosmetic goods. There is a great desire for more information about NT and its applications, as well as the necessity for clear labeling and transparency. We also observed a high number of respondents who reported a non-attitude toward NT, suggesting an increase in information initiatives and media coverage. Sex, education, and age have varying but rather low effects on the perception of NT, most notably on knowledge and awareness. Surprisingly, the attitude was affected neither by age nor education, showing that educational institutions do not have the measurable influence we expected and hoped. Special consideration must be given to our finding that participants with a negative attitude toward NT are less prone to engage with information about the topic that might educate them or change their perception. For this transdisciplinary technical field, new approaches to more effective science engagement, education, and communication are required.

Furthermore, it is crucial to facilitate a well-educated public debate since active societal involvement is deemed essential for NT risk governance in the future. Naturally, all findings must be interpreted carefully and within the limitation of the data available in this study. The absence of random sample in any online poll and the probable exclusion of non-technophile segments of the population are other potential limitations of the study.

The goal of this study was to assess university students knowledge about NT and the impact of their demographic variables on that knowledge using a range of assessment questions. According to the findings, most B.Sc. participants are aware of the definition of NT. There is a weak relationship between educational level, gender, age, and kind of employment with awareness of NT. There is no link between educational level, gender, age, or type of employment regarding NT exposure. Most Egyptians believe that NT has a good impact on human health, and NT positively impacts human health for both men and women. All participants, regardless of educational level, disagree that NT positively impacts human health. Except for housewives, all employees disagree about the usefulness of NT on human health. Egyptians agree that NT is currently in use, even though the effects on human health and the environment have yet to be thoroughly investigated.

This study provided important insights into a wide range of problems, and it recommends further investigation into those issues through the use of more surveys with larger sample sizes and expert advice on what the general public should know about nanotechnology.

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DECLARATION

We confirmed that we have read, understand, and agreed to the submission guidelines, policies, and submission declaration of the journal.

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Authors' contributions

We confirm that all authors listed on the title page and in this form have contributed significantly to the work, have read the manuscript, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission to this journal.

Ethics approval and consent to participate

We confirm that all authors of the manuscript have no conflict of interests to declare.

Consent for publication

We confirm that the manuscript is the authors' original work and the manuscript has not received prior publication and is not under consideration for publication elsewhere.

Availability of data and material

We confirmed that all data and materials are available once it required.

Competing interests

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