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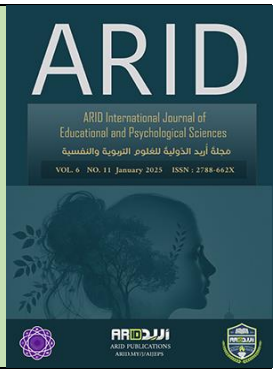

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دور تعليم العلوم في مواجهة التضليل للمعلومات العلمية لدى طلاب الجيل Z

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The Role of Science Education in Combating Scientific Misinformation among Generation Z Students

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ABSTRACT

This study addresses the phenomenon of scientific misinformation, which refers to the spread of false and misleading scientific information through social media and its impact on Generation Z students, also known as digital natives. It highlights the need to redirect science education to confront this issue and enhance scientific literacy among these students. Using a descriptive-analytical approach, the study aims to define the nature of Generation Z and its key characteristics, and identify the concept of scientific misinformation, its main issues, and ways to combat it in society. Furthermore, the study explores the reasons for the need to redirect science education to tackle scientific misinformation among Generation Z students. Finally, it presents a set of recommendations to strengthen the role of science education in combating scientific misinformation, including incorporating issues of scientific misinformation into science curricula at all educational levels, fostering critical thinking skills and the ability to analyze and evaluate scientific information, and promoting scientific discussions in classrooms to build a strong understanding of science and enhance scientific awareness among students of this generation.

Keywords: Scientific Misinformation, Scientific Disinformation, Science Education, Generation Z, Social Scientific Issues

الملخص

تتناول هذه الدراسة ظاهرة التضليل العلمي وتعني انتشار المعلومات العلمية الزائفة والمضللة عبر وسائل التواصل الاجتماعي وتأثيرها على طلاب الجيل Z، المعروفين بالبشر الرقميين، حيث يتعين إعادة توجيه تعليم العلوم لمواجهة هذه المشكلة وتعزيز الوعي العلمي لدى هؤلاء الطلاب، ومن ثم حاولت الدراسة - باستخدام المنهج الوصفي التحليلي للأدبيات والدراسات السابقة ذات الصلة- تحديد ماهية الجيل Z وأهم خصائصه، وتحديد المقصود بالتضليل العلمي وأهم قضاياه وسبل مكافحته في المجتمع، كما أوضحت أسباب الحاجة لإعادة توجيه تعليم العلوم لمواجهة التضليل العلمي لدى طلاب الجيل Z وأخيرًا قدمت مجموعة من التوصيات لتدعيم دور تعليم العلوم في مواجهة التضليل العلمي لدى طلاب الجيل Z، تضمنت ما يلي: تضمين قضايا التضليل العلمي في مناهج تعليم العلوم في كافة المراحل التعليمية، ضرورة تعزيز وتنمية مهارات التفكير الناقد والقدرة على تحليل وتقييم المعلومات العلمية وفحص وتقييم المصادر العلمية وفق الأدلة، تشجيع المناقشات العلمية في الصفوف الدراسية لبناء فهم قوي للعلم وتعزيز الوعي العلمي لدى طلاب هذا الجيل.

الكلمات المفتاحية: التضليل العلمي- تعليم العلوم- الجيل Z- القضايا العلمية الاجتماعية

Introduction

Man lives in an ever-evolving world and must have reliable knowledge about the safety of the air he breathes and the food he eats, relying on science, which in turn relies on the best available evidence to make decisions related to public health and the environment. However, we face a challenge in dealing with scientific misinformation that distorts the picture of real evidence and hinders understanding the potential harms of any human behavior. There is a need to promote scientific literacy and increase students' awareness of the importance of scientific evidence in decision-making. Therefore, it requires us as science teachers and scientific intellectuals to explain the importance of science and trust in it to society and students and provide them with the knowledge necessary to evaluate information in a critical and conscious manner. Therefore, teaching and educating science is vital because it is the way to meet such a difficult challenge.

Science is one of the most important tools that contribute to the development of humanity and raising the level of knowledge.

However, scientific misinformation poses a serious threat to scientific knowledge. When individuals deal with information, they often rely on experts and researchers recognized in the scientific field. However, scientific misinformation exploits this trust in experts by presenting some fake or unqualified researchers who promote misleading ideas; these ideas are promoted as scientific and are incorrectly documented or distort real scientific findings to suit distorted agendas.

In other words, the spread of false information online threatens trust in science. This includes misinformation that is transmitted unintentionally and misinformation that its promoters know full well to be inaccurate, and this misinformation undermines trust in science and poses an individual and collective risk. For example, the belief that vaccines cause autism puts the lives of those who believe this at risk; therefore, awareness must be raised about the importance of obtaining information from reliable sources and verifying its accuracy before publishing or adopting it (Osborne, et al, 2022).

Generation Z students are digital natives who have grown up in the age of digital technology and the Internet. Despite their presence in a digital world, not all of them are digitally literate. Teenagers in this generation suffer from the negative effects of their screen time, and this is more evident than in younger children. They spend a lot of time on electronic devices and little time reading books, which affects their ability to concentrate and their school performance and may also affect their future (Information and Decision Support Center, 2022).

Interest in public issues such as environmental issues, social justice and volunteer work is an important aspect of Generation Z. Their wide participation in most social protest movements in various societies is noted, for example: Generation Z considers the "threat of climate change" a disaster that affects their lives, according to a National Geographic report. In the period before the Corona pandemic, Amnesty International asked 10,000 people from Generation Z between the ages of 18 and 25 in 22 countries to identify the most pressing issues in the world, global warming received the highest votes, 41% of respondents. In America specifically, the vast majority (87%) of Generation Z reported that they are concerned about the environment and the planet (Ahmed, 2023).

This calls for the need to pay attention to students of this generation in particular, given its characteristics that make it largely coexist online, and given its interest in global and environmental issues. Science education, science education, and the development of critical thinking skills are powerful tools in confronting scientific misinformation and enhancing scientific awareness among students.

Some studies, including (Osborne, et al, 2022), (West & Bergstrom, 2021) (Allchin, 2023), (Allchin, 2021), have confirmed the need to develop science education in schools and across educational curricula in order to confront the phenomenon of scientific misinformation that has swept various social media and necessitated a re-understanding of the nature of science to include a modern view that includes scientific media culture and confronting misleading information.

The Problem:

New variables have emerged in society, namely the spread of false and misleading scientific information through social media, which calls for the need to reconsider the understanding of the nature of science and the role of science education in confronting scientific misinformation among Generation Z students known as digital humans. Considering the above, the study problem is determined by answering the following questions:

1- ***What is Generation Z and what are its most important characteristics?***
2- ***What is meant by scientific misinformation, what are its most important issues, and how can it be combated in society?***
3- ***Why should science education be redirected to confront scientific misinformation among Generation Z students?***
4- ***What are the proposed recommendations to support the role of science education in confronting scientific misinformation among Generation Z students?***

The Objectives:

1. Define the concept of "Generation Z" and clarify its most important characteristics and distinguishing features.
2. Clarify the concept of scientific misinformation and identify its most important issues and negative effects on Generation Z, with a focus on the spread of false and misleading scientific information through social media.
3. Exploring the role of science education in confronting scientific misinformation among Generation Z students, and identifying educational procedures that can enhance scientific awareness and develop critical thinking skills among this generation.

Importance of the study:

1- The study can benefit those interested in science education by highlighting the importance of the role of science education in confronting scientific misinformation and enabling Generation Z

students to distinguish between correct and misleading information, thus contributing to improving their ability to make correct and informed cognitive decisions.

2- The study can benefit researchers in science education by highlighting a new research area: scientific misinformation.

3- The issues of scientific misinformation presented by the current study can be used to include them in science curricula at different educational levels, as well as the skills that must be developed among science learners to detect misleading information.

4- Benefit from the recommendations provided by the study regarding the role of science education in confronting scientific misinformation.

Methodology

The current study relied on the qualitative approach, specifically the integrated literature review approach, to evaluate and analyze studies and literature related to scientific misinformation and its impact on teaching and learning, which is a distinct means of collecting and integrating research results, providing convincing evidence, and discovering areas for future exploration.

The Results

The current section addresses the study questions by reviewing the literature closely related to the study problem as follows:

First question results:

The first question states **(What is Generation Z and what are its most important characteristics?)** By referring to the literature and previous studies in this field, it was possible to answer the question as follows:

Generation Z

The concept of "Generation Z" (Z Generation), which is the generation following the millennial generation, and most sources agree that it includes individuals born between the late nineties (in 1997) and the early decade of the twenty-first century (in 2010).

Individuals of this generation are distinguished by their proficiency in using technology because they were born during a period characterized by tremendous technological development. Before Generation Z was more accurately distinguished, they were often combined with the millennial generation; Because the two generations share some similarities, some of these common characteristics are progressive political views, ease with technology, a presence on social media, and a focus on personal finance (Dolot, 2018).

In 1995, the Internet emerged. Since then, Generation Z has been born, and the largest cohort of this generation after the millennials arrived at college in 2013, and more than four years later, classrooms and college programs are filled with Generation Z students. In order for educators to effectively attract, educate, and graduate this new cohort, they must understand the general characteristics and styles of these students. In 2014, a study was conducted on more than 750 Generation Z students in 15 educational institutions of varying sizes and types in several countries. The study provided insights into this generation's views, styles, preferences, concerns, and beliefs regarding politics, religion, motivation, communication, social issues, community engagement, relationships, leadership, and learning. The results indicated that Generation Z shares some characteristics with the Millennial generation, but it is a completely different generation. The design of current campus environments is designed for previous generations, which cannot fully meet the needs, interests, and learning preferences of Generation Z students, so it is necessary to develop education that suits the nature of this generation (Seemiller; Grace, 2017).

Basic characteristics of "Generation Z:"

"Generation Z" is characterized by several basic characteristics (Dolot, 2018), (Information and Decision Support Center, 2022):

1. Digital generation: "Generation Z" was born in the age of digital technology and the Internet and uses the Internet and social media extensively. They enjoy an abundance of information and the ability to communicate and learn through technological innovations.

2. Practical and financially minded generation: "Generation Z" individuals are characterized by interest in money and pragmatism, because of witnessing the financial crisis that previous generations experienced. They are keen to learn the concepts of money and make informed purchasing decisions.
3. Mental and psychological health challenges: Generation Z faces mental health challenges, such as social isolation and depression, due to spending too much time in front of screens and lack of real-life communication. They also have a higher awareness of mental health issues and are more prone to sleep problems and stress.
4. Smart consumer generation: Generation Z relies on social media and technology to make decisions. They are characterized by their ability to explore and evaluate options thanks to technology, and they may be more influenced by recommendations from ordinary users rather than celebrities.

In general, Generation Z is characterized by technology, financial awareness, and mental health challenges. They have great potential for learning and communication, but they face unique challenges arising from the digital world in which they live, which calls for the need to protect them from the negatives of living in this world and trying to enlighten them about the nature of the information they receive from it.

(Ichsan, et al, 2023) indicates the importance of teaching Generation Z students 21st century skills. This study proved, through meta-analysis of 16 studies of science education and STEM studies from prestigious national and international journals, that science education is effective in developing 21st century skills among Generation Z students, including skills related to information and media culture and scientific communication, as students of this generation are distinguished by their ability to deal digitally to a great extent, communicate effectively, and access most forms of information and data.

Considering the above, the need to pay attention to this generation category becomes clear due to its distinctive characteristics, the most important of which is its great interaction with technology and social media, and its enjoyment of digital skills and virtual communication. This calls for the need to identify the extent of their ability to evaluate the scientific information they access and how they can judge whether the information is reliable or misleading to them, which is what the current study calls for through science education.

Results of the second question:

The second question states **(What is meant by scientific misinformation, what are its most important issues, and how can it be combated in society?)** By referring to the literature and previous studies in this field, the question can be answered as follows:

The concept of scientific misinformation

Misinformation is the process of concealing and distorting facts, and using methods of deception, fraud, and camouflage to convince others of the validity of incorrect or false information. Misinformation includes distorting facts and falsifying facts to convince others that what is being presented is the correct truth, even though it is not true. Misinformation is used to push others to make wrong decisions or adopt false opinions based on misleading or incorrect information (Samida, 2018).

A distinction can be made between the terms (Misinformation) and (Disinformation), as they are two terms used synonymously in the context of the process of misinformation of information, as the term "Misinformation" refers to errors or fake news that spreads without any deliberate intention to mislead. This includes mistakes made by individuals unintentionally or by mistake, such as forgetting or misunderstanding information, and it can spread easily in the age of modern technology due to the presence of social media. As for "Disinformation", which means distorting facts, it is a type of misleading information that is deliberately spread for the purpose of misleading and manipulating. These types of information often include guidance by governments or intelligence agencies for the purpose of

political or military influence or using it to promote certain agendas, and it often has strong and destructive effects, and is used as a means of political or military influence and manipulation (Kelly, 2022).

The current study is interesting in both, as the issue of scientific misinformation, whether intentional or thorough misunderstanding, is a real crisis that science education must address at all educational levels. (Vraga & Leticia, 2020) define scientific misinformation as information that is incorrect based on the best available evidence from relevant experts at the time, and (Paquin, et al, 2022) add that scientific misinformation is an alarm or message that presents a false proposition as if it were true.

(Brian, et al, 2022) distinguish between scientific misinformation and other possible forms of misinformation, such as political misinformation, by looking at what we know about science as a process of inquiry in an attempt to explain what distinguishes scientific efforts from others, and thus scientific misinformation is related to information related to science, its processes and the scientific research it produces, as well as information related to industrial products associated with science and engineering.

Thus, scientific misinformation can occur for several reasons, such as ignorance or lack of scientific understanding, or being influenced by personal biases and beliefs, or malicious intent to distort the facts or promote certain agendas. Scientific misinformation may include the spread of fake news, distortion of scientific studies, ignoring strong evidence, or deliberately presenting incorrect information. Scientific misinformation can be combated by providing reliable sources of scientific information, and raising scientific awareness about the importance of verifying sources and evaluating information based on reliable scientific evidence, which science education must address. Scientific misinformation can be defined as the process of distorting or providing misleading or incorrect information in the context of science and scientific research and spreading it through social media to influence public opinion, distort

scientific results, and provide false or misleading interpretations of scientific data. This causes negative effects on students and society in general.

By extrapolating some studies, including (Mitnick & Sim, 2003) (Roozenbeek, et al, 2019), (Paquin, et al, 2022) (Naomi& Erik, 2010) on misinformation, several forms of it can be distinguished as follows:

1. Media misinformation: It is represented in directing information in a way that distorts the facts or presents them in a false or exaggerated manner. This may include using misleading headlines or directing attention to only certain aspects of the truth to distort the general orientation of the reader or listener.

2. Scientific misinformation: It occurs when incorrect or distorted scientific information is presented with the aim of supporting a specific agenda. Reliable research may be ignored or the results may be distorted to suit personal or political interests.

3. Linguistic/verbal misinformation: It depends on the use of words or phrases in ways that deceive the public and change the true meaning of concepts. Linguistic misinformation is used to achieve a specific agenda or cover up the real facts.

4. Statistical misinformation: This involves the use of statistics in distorted or incorrect ways to direct public opinion. This can include using unrepresentative samples or presenting numbers in ways that mislead the reader and distort basic concepts.

5. Emotional misinformation: It relies on exploiting emotions and feelings to influence decisions and beliefs. This is done by arousing fear, anger, pity, or love in an exaggerated or unfair way to manipulate people's perception and decision-making.

There are certainly other forms of misinformation that occur depending on the context in which they are found. There is misinformation that occurs with images and videos and misinformation that occurs in certain professions rather than others, but the current study is concerned with scientific misinformation, which occurs in the context of science, its research, and the issues that have arisen around it.

Scientific Misinformation Issues

Over four decades, a group of influential scientists and scientific advisors, who have close ties to politics and industry, have emerged and led effective campaigns to mislead individuals and deny confirmed scientific knowledge over four decades. These are the same individuals who appear time and again—some of whom have claimed that climate change is "unsettled science"—have denied the truth of studies linking smoking to lung cancer, coal smoke to acid rain, and CFCs to the ozone hole. It is time to expose this dark side of the scientific community, and to show how society's understanding of some of the most important issues of our time has been shaped by ideology and corporate interests, backed by a very compliant media. And to show how this group has used disinformation and skepticism tactics to cast doubt on scientific evidence and serve their own interests at the expense of public health and the environment. It is also important to understand the influence that corporations and politics have on society and distort its understanding of vital issues that affect the world (Naomi & Erik, 2010). There are many issues of scientific misinformation raised by scientific research in the current era, which relied heavily on casting doubt on scientific research and spreading misleading information with the aim of distancing society from the truth for political, economic or social interests. These issues can be integrated into science education curricula according to the nature of the stage in which they are taught, including the following:

1- The issue of smoking and cancer / "Big Tobacco Doubt Manufacturing" campaign

A famous issue in which scientific misinformation occurred is the issue of "smoking and cancer". There has been widespread misinformation for a long time about the relationship between smoking and cancer. Tobacco companies have tried to distort scientific facts and provide misleading information to society with the aim of confusing the close links between smoking and cancer. Many scientific studies have been studied and documented that have shown a strong link between smoking and an increased risk of various types of cancer, including lung cancer, cancer of the mouth, throat, esophagus, bladder, pancreas

and others. However, tobacco companies have used distorting strategies to cast doubt on these results and promote the idea that there is no direct link between smoking and cancer. However, thanks to the continuous efforts of researchers and health organizations, the scientific link between smoking and cancer has been conclusively confirmed. Strict measures have been taken to limit the use and promotion of tobacco products and to educate the public about the health risks of smoking. This case is a prominent example of misleading society by falsifying scientific facts in order to achieve financial gain or other interests (Michaels, 2022, 22).

One of the most famous examples of this case is the so-called Big Tobacco "Manufacturing Doubt and Uncertainty" pamphlet. One of the main strategies of the Big Tobacco pamphlet is to push scientific experts to question scientific evidence, market it in "product defense" and use it by companies keen to avoid addressing the harms caused by their products. These campaigns are complex and go beyond simple public relations to convince the press and the public that the science is uncertain. Companies often sponsor research with pre-conceived results and publish them in what appear to be credible scientific journals. In the Big Tobacco campaign, the industry was defended by causing confusion and uncertainty, as evidenced by a memo penned by a tobacco executive that stated: "Doubt is our product because it is the best way to compete with the 'body of truth' in the minds of the general public. It is also a way to generate controversy." The tobacco brochure has continued to serve as a model for the behavior of many companies. It represents the base of dark money, where corporations and wealthy individuals fund institutions set up as "educational" nonprofits that aim to sow confusion and uncertainty about everything from climate change to toxic chemicals to the health effects of sugar-sweetened soft drinks (Michaels, 2022, 22).

2- Climate Change and Climate Denial

Climate change is one of the most significant environmental challenges facing the world today. However, there are

A group of individuals and organizations that deny the existence of climate change or question the scientific evidence related to it. Although there is a broad scientific consensus that human activities are the main factor in climate change, there are efforts to limit or deny this scientific evidence. Forms of scientific misinformation on the issue of climate change may include the manipulation of scientific data, the dissemination of incorrect or unsupported information, and questioning the authority of scientists and scientific institutions concerned with studying climate change. Continued climate denial affects efforts to combat climate change and take the necessary measures to reduce its negative effects (Kahan, 2015).

Climate change skeptics have claimed that the expansion of sea ice in 2014 is indisputable evidence that concerns about climate change are unjustified. Moreover, the expansion of sea ice in a warming environment is abnormal. However, a closer examination shows that there are flaws in the skeptics' argument:

First, there is a confusion between climate change (a long-term pattern spanning decades, if not centuries) and weather (short-term changes in local atmospheric conditions). What matters is the long-term trend, which is not affected by short-term exceptions.

Second, the water released by melting ice is freshwater, which is less dense than seawater and therefore floats to the surface. In addition, freshwater freezes at a higher temperature than seawater and produces more ice. The overall answer to this question is complex and still not fully understood by scientists. However, most outside experts cannot be expected to be able to identify flaws in such claims (Osborne, et al, 2022).

3- Vaccine Vaccination and Doubt

A case of scientific misinformation in which incorrect information and rumors about the effectiveness and safety of vaccines have been spread. Although vaccinations have been proven effective in

preventing infectious diseases and improving the health of individuals, there are a number of groups that question the benefits of vaccinations and promote information that is not scientifically based.

This scientific misinformation can lead to a decline in vaccination rates and an increased risk of infectious diseases and serious health complications. In addition, questioning the effectiveness of vaccinations can contribute to spreading fear and anxiety among members of society and disrupting mass vaccination efforts, which in turn affects public health (Streefland, 2011).

4- The issue of the impact of agricultural pesticides on human health:

Another issue is related to scientific misinformation, as agricultural pesticides are used to reduce agricultural pests and increase productivity, but there is a growing trend towards studying their effects on human health. Scientific evidence indicates that some agricultural pesticides can be harmful to human health and are associated with an increased risk of diseases such as cancer, hormonal disorders, and other chronic diseases. However, scientific misinformation is used to question this evidence and minimize the risks of agricultural pesticides to human health. Suspicious or unreliable studies are published that attempt to justify the safety of these pesticides and ignore the potential harmful effects. Individuals are exploited by raising doubts and discrepancies in scientific research, thus denying or ignoring the real warnings about the effects of pesticides on human health. (Thompson, 2017) .

5- The Impact of Sugar on Health

This issue revolves around the negative effects of excessive sugar consumption on human health and the relationship between sugar and chronic diseases such as obesity, heart disease and diabetes. There is a trend to mislead individuals about the effects of sugar on health, as the idea is promoted that sugar is harmless and has no relation to these diseases. However, there is strong scientific evidence to support the idea that consuming large amounts of sugar can be harmful to health and contribute to an increased risk of chronic diseases.

One example of this is the International Life Sciences Institute (ILSI), a global non-profit organization with a stated mission to provide transparent scientific research in pursuit of a "healthier world." ILSI, founded by a Coca-Cola executive, has cast doubt on the US guidelines on sugar and the relationship between sugar and obesity. In 2019, a qualitative analysis of ILSI documents concluded that ILSI is a scientific front for the food and soft drink industry, working to influence public health and food policies around the world (Roozenbeek & van der Linden, 2019).

6- The Impact of Mobile Phones on Health

This issue addresses the controversy and questions about the impact of mobile phone use on human health, including electromagnetic radiation from phones and potential health effects. There are various concerns and perceptions about the effects of electromagnetic radiation from mobile phones, such as increased risk of cancer and effects on fertility, sleep, and concentration. However, current scientific evidence shows that there is no strong evidence to suggest that regular mobile phone use has significant negative effects on human health. It is of utmost importance to rely on reliable scientific information and verify its source, as evidence is based on peer-reviewed scientific studies and independent scientific evaluation to determine any potential health effects of mobile phones (Suarez-Lledo, et al, 2021).

7- The issue of the spread of misinformation during the Covid 19 Crisis

Misinformation has led to the spread of rumors and false news about the Corona virus, its transmission methods and treatment. This has undermined confidence in health authorities and distorted the public image of efforts to combat the virus. It has also been affected Individual behaviors have been greatly affected by misinformation. Some misinformation has raised fear and public panic, and led to tension in social relations and general tension between individuals. Some individuals have relied on incorrect information and ignored the recommendations of experts, health authorities and precautionary measures, which caused the virus to spread further, exacerbated the crisis and negatively affected efforts to control it (Loomba, et al, 2021).

8- The issue of concealing the health risks of some medicines

The issue of misinformation about some medicines includes many practices that aim to distort information related to the effectiveness and safety of medicines, such as publishing incorrect or misleading information about the benefits of the medicine while ignoring or concealing side effects or research indicating the ineffectiveness of the medicine, as well as providing incorrect or misleading information in drug advertisements. Language may be manipulated or the benefits of the medicine may be focused on in an exaggerated manner without highlighting the side effects or existing limitations. Incorrect or supplementary information may be directed to doctors and health practitioners to encourage them to prescribe more or without taking into account the available scientific evidence. To address this issue, it is important to have a strong system for monitoring and reporting the side effects and health risks of drugs for patients, doctors and society at large (Naomi & Erik, 2010).

9- The issue of ignoring the role of Arab scientists in the renaissance of science

Some evidence and studies indicate that there is some misleading and misrepresentation in the interpretation and documentation of the history of Arab scientists and their role in the renaissance of science, due to various factors such as politics, racism and cultural bias. This is partly due to the changes that the region has witnessed throughout history and the external influences that have left their mark on the Arab scientific heritage. Historically, the Arab Middle Ages are an important period for scientific progress in the Islamic world, as Arab scientists contributed to many fields such as medicine, mathematics, astronomy, philosophy and chemistry. However, some studies indicate that there is a cultural bias that affects the appreciation of science among Arabs and reduces its contributions, and this can lead to misleading or neglecting some important Arab scientific achievements. In protest against this misleading and neglect, there are efforts to rediscover and highlight the Arab scientific legacy, through research and conferences that highlight Arab scientists who have made important contributions to the development of science (Montaser, 2012).

The matter is not limited to the issues I mentioned above, as there are many issues in which scientific misleading and the dissemination of false or incorrect information takes place. Every scientific product has its positive and negative consequences, and its negative effects are often hidden, especially if this product achieves scientific, social, political or material gains. There is also the issue of the spread of blogs, forums and videos that talk about topics of science and scientists and do not have reliable sources, but rather a mere narration of information that the recipient cannot verify its credibility unless he has scientific awareness, critical thinking skills and information evaluation skills, which is also a scientific issue worthy of study.

Scientific misinformation issues can be defined as issues that arise as a result of using practices and methods to distort scientific facts and evidence to direct individuals towards incorrect or misleading beliefs or information with the aim of achieving certain agendas or achieving personal, material or political gains, which science education must address across the various educational stages in order to develop students' awareness of them and provide them with skills to confront scientific misinformation.

Ways to combat scientific misinformation in society:

A system is needed that develops relevant scientific evidence before individuals are harmed. Companies whose products may be harmful should be required to fund studies to evaluate those concerns. However, for studies to be credible, funders should have no role in developing the research, selecting the researchers or methods used, or reporting the results. This is the only way to extract the truth and restore confidence in the process of using science to protect public health and protect future generations. In the meantime, increasing public awareness of product advocacy and its methods of confusion and doubt will make it harder for polluters and manufacturers of dangerous products to continue harming the public's health (Michaels, 2022).

The Science Media Centre Spain (SMC Spain) – a centre specialising in disseminating science in the media through expert sources and the best available evidence in order to improve the quality of public

debate on scientific issues – has developed a set of recommendations for dealing with misinformation. The results of the survey on scientific misinformation in Spain, conducted by FECYT within the framework of the European project IBERIFIER, indicate that most individuals are concerned about the effects of scientific misinformation and do not feel confident when it comes to distinguishing between false and true content. These recommendations include:

1- Promoting media literacy among members of society

Given their important role in being able to distinguish the validity of scientific issues and limiting the spread of misinformation, there is a need to strengthen the competencies that enable members of society to engage critically and effectively with information, with other forms of content, with different sources and the ability to verify scientific information, and with different types of dissemination methods.

2- Increase knowledge of how science works

Society must be able to understand the temporary/changing nature of science, so that a new discovery can override previous knowledge, and this is far from the problem of distrust in science, and that trust must be strengthened as an activity subject to continuous judgment.

3- Enhance knowledge about the social practices used by the scientific community to produce reliable knowledge and the standards of scientific expertise

Scientific knowledge is highly specialized, and because of the limits of our knowledge and time, we often rely on the expertise of others, so society may use their trust in experts or institutions to enhance:

a) Knowledge about the social practices used by the scientific community to produce reliable knowledge, such as the importance of consensus or peer review.

b) The ability to question the reliability of the source and specialized scientific expertise in the field in question (Osborne & Pimentel, 2022).

Misleading information spread by scientists in various media, especially on social networks, must be avoided. This occurs when various science and health professionals broadcast news that they do not have the expertise or ability to distinguish its validity, and society is often unable to evaluate their ability to do so. Sometimes this misinformation is not false, but is simply not adequately communicated and loses its accuracy.

4- Enhancing skills for "healthy" skepticism

Trust in institutions, increased trust in science, greater knowledge about how science works, and conspiratorial mindsets are all linked to concerns about misinformation, which can help alert individuals to the dangers of misinformation. In this sense, it is important to foster skills for practicing "healthy" skepticism—the ability to accept evidence—as opposed to absolute skepticism about anything related to the official, evidence-inoculated narrative of conspiracy thinking.

5- Avoiding politicization of scientific facts

Ideology can play a role in identifying and spreading scientific misinformation, which highlights the importance of avoiding "politicizing" scientific findings and distinguishing them from political actions or decisions, in which social, economic, ethical, and other factors also play a role.

6- Promoting responsible and good scientific communication

Although social media play an important role in spreading scientific misinformation, individuals tend to reduce the credibility of these channels, it is necessary to enhance the quality of scientific communication by the media and organizations, in order to avoid misinformation and build community trust in these organizations.

7- Promoting specialized scientific journalism

Specialized scientific journalism should be promoted, without losing its independence and critical capacity, which allows scientific results to be placed in context, conveys the temporary nature of science as a force and avoids the "misleading balance" in the media, presenting a case as more balanced between

two opposing views than the evidence supports. This does not mean that society cannot have a say in the effects that scientific results or their applications may have, but it is important to distinguish them from the facts. In this regard, initiatives that provide resources for the media to cover scientific news, such as the Media Science Centers or the European Science and Media Center, are useful.

8- Promote specialized means and resources dedicated to scientific communication

Scientific institutions play an important role in promoting means and resources dedicated to scientific communication that include society, and can provide effective and responsible information, avoid exaggerating scientific results, communicate uncertainty and enhance knowledge of how science works.

9- Take measures to limit the spread of misinformation promoted by algorithms

It is important to work with search engine and social media algorithms to punish misinformation, as existing algorithmic biases (such as reactive bias) often increase the spread of hoaxes, in addition, competition for attention and the use of tactics favored by these algorithms can encourage scientists

Considering the above, scientific misinformation can be combated in society by promoting media literacy, increasing knowledge of the role of science and scientific practices, and awareness of the importance of verifying and critically evaluating information. It is also necessary to build a culture that recognizes the importance of healthy skepticism based on knowledge while avoiding politicizing scientific facts and using them for political or ideological purposes. The independence of science must be maintained, and evidence and specialized expertise must be relied upon in making and taking decisions. By adopting these measures, a society can be built that has confidence in science and supports correct scientific knowledge and does not fall prey to scientific misinformation.

Results of the third question:

The third question states (Why should science education be reoriented to confront scientific misinformation among Generation Z students?) By referring to the literature and previous studies in this field, it was possible to answer the question as follows:

First: The path of scientific information and how scientific misinformation occurs

Höttecke & Allchin, 2020 refers to the path of scientific information between two media: The first: is the community of scientists that produces the paper or scientific research through scientific processes that include experimentation, observation, interpretation, and inference, then obtaining scientific consensus to publish this research. The second: is the scientific communication that occurs in society in general. Information may be obtained either through cognitive filters and gatekeepers in the media, and here the scientific information reaches the citizen who consumes science correctly, or the information reaches from another path, which is imitators of science or mercenary science to use deceptive tactics to deliver misleading information and false scientific claims to the citizen who consumes science. This may happen with the help of social media in both paths.

In this regard, the Union of Concerned Scientists (2019) noted that there are five deceptive strategies in popular science media, which are identified by the acronym LIARS:

- **Looks:** Professional appearance and confident manner.
- **Identity:** Appealing to social connections as a substitute for cognitive trust.
- **Acting:** Fake credentials or irrelevant expertise, camouflage.
- **Repetition:** Flooding the media with the same false message.
- **Skepticism:** Exaggerating skepticism and using it to one's advantage.

Second: Reasons for science education to address the phenomenon of scientific misinformation

The common assumption is that Generation Z students are digital natives, but there is evidence to suggest that this is not the case, as young people and adults have difficulty evaluating the information they encounter online. A 2019 national survey showed that students have a significant weakness in their ability to evaluate the credibility of online sources. Although students acknowledge that they will rely on the credibility of the information source in Their assessments, however, ignore the sources and rely on superficial features such as the visual appearance of the site or the relevance of the information

provided. Simply put, students may be tech-savvy, but they are still novices in their ability to evaluate the credibility and quality of information. They lack basic guiding tools to help them avoid online deception (Breakstone, J., et al, 2021).

One might ask, why should science education play a role in developing students' digital literacy and media skills, and is this not the responsibility of civic education? Additionally, are these issues part of the Next Generation Science Standards (NGSS) in the United States? While these arguments are understandable, the context has changed dramatically since the standards were created. The challenge facing science today in the age of misinformation is a serious one that requires an educational response from science educators. Why? Because many of the issues we face today have a scientific basis. In 2021, questions such as: Are masks necessary to control the spread of COVID-19? Is climate change the cause of floods, droughts, and other extreme events? Are vaccines effective? How dangerous is the Omicron strain of COVID-19? And how can we prevent wildfires and mitigate flooding?

In addition, there are persistent questions such as: Are genetically modified foods safe to eat? How can we best reduce pollution? And how can I live a more environmentally friendly lifestyle? So how can people who are not experts in science answer these questions? These are questions that require an understanding of how science produces reliable knowledge, which can clearly contribute to informed and reliable answers. If scientists, science educators, and producers of scientific knowledge do not inform their communities about the causes and the reliable sources, others will fill the void (Osborne, et al, 2022).

The reality that underscores the importance of science is that even anti-vaxxers and climate change deniers commonly use the language of science to spread misinformation, using it to cast doubt on the scientific consensus. For example, the fossil fuel industry promotes "scientific" claims about climate change. Often, sowing doubt is all that is required to challenge the authority of scientific findings, even when there is broad, international, and diverse consensus from the scientific community. Understanding

the importance of consensus in science requires some knowledge of how it is produced by scientists and their social practices. Science educators must therefore explain why and when scientific claims can and cannot be trusted in public discourse (Oreskes, 2019). In this regard, Osborne et al. (2022) explores how science education can meet its responsibility to provide all students with the skills needed to navigate this sea of false and questionable information without being misled, confused, and, most importantly, deceived. In doing so, four questions are explored:

1. Why do students need to be able to evaluate scientific expertise and information?
2. What evidence is there that young people struggle to evaluate information effectively?
3. Why is it essential and urgent for scientists and science educators to develop students' competence in evaluating information?
4. What can scientists and science teachers do to develop competence in evaluating scientific information and expertise?

The study confirmed that science education has not been able to teach students all the knowledge they need for their entire lives, no matter how well it is explained. Therefore, it is easy for people to be deceived by individuals who resort to using the language of science in their arguments, so students' skills in evaluating scientific expertise and information must be developed. It also stressed the need to provide the necessary educational tools to develop this competence and enable students to make informed decisions based on reliable scientific knowledge.

Considering the above, the reasons for science education's response to the phenomenon of scientific misinformation can be summarized as follows:

1. Weak information evaluation skills: young people and adults alike suffer from a weakness in their ability to evaluate the credibility of information they encounter online. They may rely on superficial features such as the visual appearance of the site or the relevance of the information provided instead of relying on the source and credibility of the information.

2. Blind trust: Generation Z students may be skilled in using technology, but they do not have the basic guidance tools to avoid online deception. They rely on blind trust instead of critical trust and accurate evaluation of information.
3. The need to develop digital culture: The digital age requires the development of media and digital culture skills among Generation Z. Science education must play a role in developing these skills to enable students to identify reliable sources and evaluate information.
4. Science and current issues: Current issues such as climate change and vaccines depend on science and scientific knowledge. Science teachers must clarify the scientific basis of these issues and explain how scientific knowledge is produced and the importance of relying on scientific evidence in making and taking decisions.
5. Challenge misleading sources: Science education must be able to meet the challenge of misleading sources and fake news that spread through the media and social networks. Students must be taught how to distinguish between correct and misleading scientific information and how to rely on reliable sources.

Therefore, the nature of science must be re-understood to include its new variables that have occurred in some of its processes, including scientific communication, and science education must update its curriculum and adapt it to these challenges to enable students to understand and evaluate scientific information correctly and develop their skills in digital and media literacy.

Third: Competencies that must be integrated into science education to confront scientific misinformation

Scientific misinformation, which spreads through the Internet and social media, has become a major problem now. Allchin (2023) describes ten competencies that appear necessary to reorient science education to meet this challenge. This study has developed these competencies in order to consider their integration into science curricula to be more complete or more accurate to confront the current crisis and

for teachers to work on developing effective classroom strategies to enhance these proposed competencies, including the following:

1- Epistemological dependence:

This includes: explaining why scientific experts are important and why non-experts (members of society) depend on them, and giving examples of the distinction between trust in experimental science and other forms of trust (belief, morality, loyalty, promise, and honesty), as social learning is deeply rooted in our cognitive structure, it must be explained why "the judgment of a scientific expert is more important than reasonableness, seriousness, political personality, or celebrity", as respect for experts is diminishing amid the ready availability of misleading information and the appeal of individual autonomy, especially in times of uncertainty in which misleading information flourishes opportunistically. Each of us needs a complete vision of the problem of epistemic dependence to understand the crisis and appreciate the importance of assessing the credibility of alleged experts, rather than relying on our own intelligence to guide us (Höttecke & Allchin, 2020).

2- EXPERTISE:

It includes describing several important criteria for identifying scientific experts. With distinguishing at least two factors that are often used to measure expertise but are not reliable. With showing these principles in the analysis of the level of expertise referred to in some reliable cases. It also includes asking important questions such as: What is scientific expertise? Who is the expert? Who is qualified to talk about justified scientific knowledge? Research indicates that even well-educated individuals are not adept at evaluating sources for their credibility. In addition, individuals tend to calibrate expertise inappropriately, for example, they may use social criteria, such as mere reputation (rumors) or authority (power) or attractiveness, which are not related to real expertise. Therefore, science teachers need to understand the nature of scientific expertise and mechanisms for verifying its validity.

3- GATEKEEPERS

It includes: describing several important criteria for identifying the official spokesperson responsible for the consensus on scientific experts. And describing at least two factors that are often used to measure their credibility - but are not reliable - with showing these principles in the analysis of the level of trustworthiness referred to in some reliable cases. Here, several questions can be asked, including: “Who speaks for science?” (Allchin, 2021). What is the origin of a particular claim? Does it reflect the consensus of scientific experts? This dimension points to a shift in attention to the challenges of mediation and the nature of science communication (the transmitter of scientific information to society). Is what the media, institutions, fact-checkers, and other gatekeepers present reliable? Do they have a track record of reliability—that is, proven expertise in science reporting? Do they have a history of journalistic integrity and independence? Are they relatively neutral (or objective), or do they consistently exhibit bias? Do they transparently indicate the sources of their information, allowing others to trace the claims or evidence? (2009; Shoemaker et al).

4- DECEPTIVE TACTICS

This includes: Mentioning the deceptive tactics used to promote unjustified scientific claims. Analyzing several samples of real claims to establish their level of credibility, as the most egregious cases of scientific misinformation are usually deliberate efforts by critical interests or ideologues. Sometimes, there are only a few sources responsible for spreading misinformation. Impersonators resort to “cheap symbols and clichés” to “evoke” the illusion of science and its authority without any actual evidence. It is often easier and faster to identify a lie than to identify an error. It is important to emphasize here that the message must be analyzed, not the sender. If the sender is not trustworthy, the message itself is worthless. Therefore, interpreting scientific claims in the media should focus on identifying conflicts of interest and finding other contexts of deception and camouflage. Another common strategy is to rely on On appeal to a philosophical principle of skepticism to directly exploit scientific uncertainty - its

implementers are called "merchants of doubt" and therefore both teachers and students need to master critical thinking to detect the most common deceptive strategies.

5- ANALYTICAL POSTURE

This includes: describing the context of scientific claims models in the media, especially who is making the claim and why (as a basis for assessing the credibility of a source), where the Internet and social media are relatively "hot" media, they elicit emotional reaction and immediacy based on high sensory input, however, in the context of assessing scientific credibility, it is The consumer-citizen needs a “cooler” and more deliberative approach or needs to activate the analytical skill of “taking one’s bearings”, so science teachers need to promote stepping back and exploring the hidden contexts of scientific claims in the media, who is speaking and why? Students need to learn how to be patient and methodical, and know when to call on that behavioral tendency to regulate one’s semi-automatic responses.

6- INTERNET AND SOCIAL MEDIA INTERNET AND SOCIAL MEDIA

This includes: Describe the challenges of confronting scientific claims on the Internet or on social media, using several examples. Teachers are now promoting a constructivist approach to learning, where students take an active role in dealing with preconceptions of the problem, developing new concepts, and modifying their prior knowledge. Inquiry learning (now widely accepted as the ideal) invites students to think explicitly about the learning process, thus building cognitive skills. The advent of Internet and social media accessibility poses a new challenge, so students must engage explicitly in cognitive problems and solve them themselves with the teacher as a guide. Science Media Literacy (SML) should also pose a problem that students are trying to investigate, for example: How do new media technologies shape behavior and beliefs? How do social networks shape behavior and beliefs in individuals?

7- Epistemological Beliefs:

Describe the circumstances in which competent scientists might justifiably disagree, using some credible examples. Describe how they might resolve those disagreements, using at least one concrete historical example. Research suggests that people who are more susceptible to conspiracy theories tend to exhibit epistemic absolutist beliefs (based on certainty and justification of personal choice). In contrast, more effective evaluation of Internet sources on social issues (SSI)—including limiting clicks, selecting items that exceed the top of web search results, and reading sideways—is associated with a more evaluative epistemic stance (constructivist, consensus-based). To foster these perspectives, science teachers should continue to focus on teaching the "tug-of-war" of scientific knowledge, highlighting how and when knowledge is qualified. This includes: (a) error and conceptual change; (b) limitations of observation and statistical uncertainty; and (c) debates in the production of science.

8- CONFIRMATION BIAS:

This includes describing the problem of confirmation bias in individuals and how to address it using some real examples. It is a common cognitive flaw in the thinking process, whether among scientists or ordinary people. This bias refers to the tendency for individuals to reinforce and confirm their existing beliefs, and ignore evidence that contradicts those beliefs. This bias is considered a blind spot in the way we generally use scientific reasoning. Ironically, confirmation bias prevents us from benefiting from available knowledge and hinders us from objectively evaluating opinions and beliefs. In fact, this bias may deepen the bias in another person's evaluation and prevent us from accessing diverse viewpoints that may help us correct false beliefs. In technological environments, algorithms, search engines, and news feeds can reinforce this bias by presenting more information that is consistent with our existing views, creating information bubbles that isolate us from different and useful information. In social networks, confirmation bias can lead to the formation of closed and insulated communities (known as "echo chambers") that can foster a sense of false consensus.

9. COGNITIVE HEURISTICS AND BIASES:

Identify at least three important cognitive dispositions that may facilitate the acceptance of unreliable scientific claims, providing a historical example of each. Identify and explain the flaws in several contemporary case studies. Educators have long advocated the teaching of critical thinking, including common logical fallacies, errors in statistical reasoning, and inherent failures in scientific reasoning, and a relevant goal in science curricula is to provide a broad sampling of such errors. We can teach students how science works by understanding the situations in which it fails, and teachers can then help students get used to relying on experts who have mastered the types of errors relevant to their particular subject. These lessons should foster respect for communities of experts who review each other's work.

10. CONSENSUS/CORROBORATION

This involves explaining the importance of consensus and corroboration from independent sources, describing what makes sources "independent" identifying at least two instances when the "community judgment" is wrong, and illustrating these with real-world examples. Philosophers now strongly support the norms of social epistemology, where trustworthiness is developed through mutual criticism (peer review, broadly interpreted at the professional community level) and expressed in general consensus, where scrutiny from multiple perspectives helps keep individual biases in check. Developing an understanding of the role of consensus adds another important dimension of reliability, beyond empirical evidence and beyond individual expertise, but science education tends to describe the "scientific method" in terms of experimentation alone, rarely mentioning the social practices of mutual criticism, finding technical flaws, exposing biases, or resolving disagreement through further investigation that science education should address. Based on the above, the competencies that Generation Z students need to develop through science education to counter scientific misinformation can be drawn from the literature.

Science literacy:

1. Explain the importance of scientific experts and why non-experts rely on them.
2. Clarify the nature of scientific expertise and mechanisms for verifying its validity and describe the criteria for identifying scientific experts.
3. Describe the official spokespersons responsible - the gatekeepers - for the scientific expert consensus. Determine their credibility and evaluate their record in preparing scientific reports.
4. Explain the tactics used to promote unjustified scientific claims and analyze the evidence presented to support those claims.
5. Promote critical thinking among students to detect common deceptive strategies and evaluate scientific claims, and understand the context behind these claims.
6. Evaluate scientific claims in the media, especially on the Internet and social media, through analysis and critical thinking to assess the credibility of sources and the validity of the scientific claims presented and achieve an objective evaluation of scientific information and avoid biases.
7. Promote scientific media literacy and encourage students to explore the impact of new media technologies and social networks on individuals' behaviors and beliefs.
8. Enhance students' cognitive skills and promote diverse perspectives to understand and accept the differences between specialized scientists on some issues.
9. Teach the idea of "confirmation bias" which means that there is a cognitive defect that makes individuals reinforce and confirm their current beliefs and ignore conflicting evidence. This will lead to the formation of information bubbles and closed communities.
10. Clarify cognitive errors, including common errors in thinking such as logical fallacies, errors in statistical reasoning, and failures in scientific reasoning.
11. Clarify cases of invalidity of "community judgment" on some scientific issues and encourage scrutiny through multiple perspectives and mutual criticism and clarify the importance of consensus and support from independent and reliable sources.

Results of the fourth question

The fourth question states (What are the proposed recommendations to support the role of science education in confronting scientific misinformation among Generation Z students?) In light of the results of the previous three questions, the researcher recommends a number of recommendations:

Science education can play a crucial role in enabling Generation Z students to confront scientific misinformation. By understanding the scientific process and developing skills of analysis, criticism, and ethical guidance, they become more able to recognize reliable scientific information and reject misleading information. Here are some recommendations to support the role of science education in this regard:

1. Developing the content of science curricula: The content of current science curricula should be developed starting from the primary stage to emphasize the need to evaluate the scientific information that learners obtain through social media, regardless of its quantity and quality, as well as integrating the issues of scientific misinformation mentioned in the current study into the curricula by studying and critically analyzing them through applied examples from online presentations that show the contradiction in presenting misleading and reliable information.
2. Enhancing the concept of scientific evidence: Science education works to enhance students' understanding of scientific evidence and its role in decision-making. They learn how to evaluate the quality of evidence, and how to draw conclusions supported by strong evidence. This enables them to verify the information and sources they encounter and rely on reliable scientific evidence.
3. Promote digital literacy and research skills: Science education helps students develop research and scientific reasoning skills in the digital age. They learn how to use search engines and online scientific resources effectively and to examine information sources. This enables them to find correct and reliable information and avoid falling into scientific misinformation.

4. Focus on contemporary scientific issues: Science education – whether formally or informally – should focus on contemporary and emerging scientific issues that the world is facing today, such as climate change, epidemic diseases, and modern technology – and the issues referred to in the current study – by exploring these issues, students learn how to analyze information and evidence related to them and direct scientific ideas and responses.
5. Develop critical thinking skills: Science education helps students develop critical thinking skills that help them evaluate information and understand scientific processes. Through the scientific method, students learn how to analyze evidence, draw conclusions, evaluate sources, and distinguish between scientific facts and false claims. This enables them to interact with misleading information and critically analyze it.
6. Promoting awareness of scientific ethics: Science education contributes to increasing students' ethical awareness. They learn about scientific ethics, research controls, and the use of valid sources. This enhances commitment to sound scientific practices and introduces them to the importance of transparency and integrity in science. This helps them distinguish reliable studies and research from those that may be unreliable or contain ethical fraud.
7. Promoting general scientific awareness: Science education contributes to increasing general awareness of science and technology. By providing basic scientific knowledge and concepts, individuals can understand the scientific foundations of various phenomena and developments. This enables them to evaluate the scientific information they receive and better understand the scientific process.
8. Promoting scientific culture: Science education encourages the building of a strong scientific culture in society. Students are encouraged to interact with science, research, exploration, and scientific questions. This helps them better deal with the information available – without gatekeeping – through various social media platforms.

Skills to counter scientific misinformation:

There is a set of skills that should be focused on in science education and developed among learners to confront scientific misinformation. They can be defined as follows:

It is a set of scientific skills and processes that should be developed among learners through science education, so that they can confront the danger of misleading and false information spread through social media. It includes four basic skills: scientific investigation skills, scientific study reading skills, critical thinking skills, and scientific source verification skills. They can be explained as follows:

1. Scientific investigation: Students must be familiar with scientific practices and how to conduct scientific research. They need to understand the process of designing experiments, collecting data, and analyzing it in objective ways.
2. Reading scientific studies: Students must be able to read and understand scientific studies. They need to know how to analyze the methodology used and evaluate the results and conclusions drawn.
3. Critical thinking: Students need to develop their ability to evaluate scientific information logically and critically. They must be able to differentiate between strong evidence and weak evidence.
4. Verifying scientific sources: Students must learn how to verify information sources and evaluate their credibility. They should rely on reliable and trustworthy sources when searching for scientific information.

In general, scientific misinformation poses a serious threat to scientific knowledge and confidence in research and development. However, by increasing scientific awareness, verifying sources, and relying on reliable scientific evidence, we can protect ourselves from it. Science education should also contribute to providing Generation Z students with the necessary tools and knowledge to actively interact with scientific information, investigate the extent of trust in that information, and the ability to confront scientific misinformation.

Suggested Research

1- Conduct research related to evaluating and developing science education curricula at all educational levels considering issues of scientific misinformation.

2- Evaluate and develop science teacher preparation and training programs considering the concept of scientific misinformation and its issues.

3- A study concerned with preparing a standardized scale to measure the level of scientific misinformation among Generation Z students.

4- A proposed vision to include issues of scientific misinformation and skills to confront it in science curricula.

5- A proposed program on issues of scientific misinformation and skills to confront it for science teacher students in colleges of education.

6- A proposed unit in science to develop skills to confront scientific misinformation among middle school students.

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