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Experts' Views on Science Communication Barriers: A Thai Perspective

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Abstract

This qualitative study investigates the factors or concerns science communicators/specialists perceive as obstacles to successful science communication in Thailand. The participants are five scientists engaged in science communication activities, two officers working as policy or science communication specialists, and five people who had received information through various science communication formats or believed in non-scientific information. The researcher examined science communication activities performed by some of the participants and conducted semi-structured interviews with twelve participants. Findings from inductive theme analysis reveal that science communicators have experienced significant obstacles, including 1) The negative impact of misapprehension about science, people's uncritical thinking, and perfunctory behaviors, 2) insufficient administrative support, and 3) inconsistency between the nature of science and the needs of audiences. In conclusion, the underlying causes of problems and obstacles are the extent to which current science education does not provide a solid foundation for people to recognize the benefits and importance of scientific knowledge in everyday life and does not encourage people to become scientifically literate.

Keywords: Science communication, Science communicator, Science education, Science literacy, Public understanding of science

Introduction

Thailand's government has announced the Thailand 4.0 policy. The primary goal of this policy is to transform the nation into an innovation-driven economy and escape the middle-income trap. Such policy focuses on various dimensions to achieve this, including: 1. Heightening economic wealth by decreasing the reliance on foreign technology through driving innovation, technology, and creativity. 2. Increasing social well-being through reducing social inequality by encouraging farmers to use agricultural technologies to create revenue and upgrading both SMEs and community enterprises with technology and innovation. 3. Attaining human wisdom through developing quality human capital, improving labor skills to suit the needs of the labor market, and following the path of national development policy. 4. Achieving environmental wellness by creating a sustainable living environment, emphasizing environmental pollution management that complies with sanitary principles (Office of Research and Educational Quality Assurance, 2016). All of these dimensions rely on science, technology, and innovation. Since science, technology, and innovation are crucial for Thailand 4.0's success, it has become necessary to raise public understanding of science and its value to encourage people to recognize the importance of science and technology.

The level of understanding and knowledge that people or society possess about scientific principles, discoveries, and their impacts on the world demands science communication by scientists or those involved in the science and technology disciplines. If science communication is successful, people will understand the importance of science in improving the country and scientific issues that affect their daily lives (Hemakirin, 2009; Intuprapa, 2017b). Through science communication, people can think critically and logically

when they are aware of and understand the nature of science.

Science communication that suits the public's context is critical for increasing mutual understanding between scientists and the public. For example, scientists' efforts to communicate the causes and consequences of global warming to the public may only succeed if they use simple language because scientific language is challenging to understand. Nevertheless, science communication must be an approach to encourage people to be aware of the impact of global warming and believe it is related (Intuprapa, 2017a). Otherwise, this problem could harm society as a whole.

Although scientists and stakeholders made efforts to carry out science communication activities (Chen et al., 2020), there are still problems related to people rejecting science as they consume various products without careful consideration. In the news, there was an example of people being arrested for selling dietary supplements and diet pills online with exaggerated claims and without approval from the Food and Drug Administration (FDA). Furthermore, those pills contain substances that are harmful to the body, and many customers waste money on them (Post Today News, 2014; Post Today News Online, 2015; Khaosod News Online, 2018; Thairath News Online, 2023).

The situation described above demonstrates the critical need to cultivate an understanding of the nature of science in Thai people and enable them to acquire a systematic analytical process based on scientific principles. Science communication by science communicators is an essential factor in this regard. Science communicators have made numerous attempts to overcome this situation, but they must strive to improve.

Research relating to challenges and barriers to science communication in Thailand has mainly focused on obtaining perspectives from participants other than scientists and science communicators, such as government officers, social influences, media, Non-Government Organizations, and academics (Pitigraisorn, 2020; Kosiyaporn et al., 2022). Despite the scarcity, the Ph. D. research conducted by Chinnalong (2015) interviewed science communicators to understand the characteristics and challenges of science communication in Thailand. However, the researcher did not include the perspectives of the public regarding the science communication barrier. The gap relating to the exclusion of public points of view leads to this research mainly focusing on directly obtaining opinions and troublesome experiences of science communicators and public perspectives relating to problems in science communications.

The abovementioned situation leads to the study's objectives: to investigate the factors or concerns that science communicators and specialists perceive as difficulties or obstacles to successful science communication and to explore public opinions and perspectives on situations of science communication in Thailand.

Conceptual framework

This study draws on the contextual model of science communication (Lewenstein, 2003), which suggests that societal and individual contexts shape an individual's interpretation of communicated scientific information. This model is relevant because it can provide a practical framework for understanding the difficulties encountered by science communicators.

The conceptual framework of this research (Figure 1) focuses on the following key elements:

- Experiences of the participants toward science communication in Thailand
- Opinions of the participants on the current state of science communication in Thailand
- The public's perspectives on science communication in Thailand

The researcher will obtain these key elements by reviewing literature relating to the history of science communication, mechanisms for improving science communication skills, science communication policy, the state of science communication in Thailand, and the contextual Model of Science Communication to outline the interview questions. Furthermore, the researcher of this study will examine science communication activities performed by the participants to understand the context of science communication activities in Thailand. The researcher will then analyze qualitative data from the interviews to explore participants' perspectives, experiences, and opinions while considering the realities of science communication activities. This analysis aims to identify the key issues and challenges in conducting science communication

activities and propose effective policies or strategies to enhance and promote practical science communication activities.

Literature review

Science and science communication

According to the American Association of Physics Teachers (1999), pure science is "a body of knowledge obtained from the systematic collection of knowledge about the world." Various laws and ideas will emerge from organizing and analyzing that knowledge. As a result, the urge for scientists to publish ideas and results from their research is a critical factor for science to gain public credibility and see its achievements. The goal is for other scientists to test and replicate it. However, suppose other scientists produce more reliable and complete experimental evidence than their own. In that case, those findings may be abandoned or modified. According to Burns et al. (2003), science in science communication refers to the science described above; this includes mathematics, statistics, engineering, technology, medicine, and other related fields.

Science communication refers to the process of distributing the results of scientific studies to a defined target group. Therefore, it is an essential element of the reciprocal connection between science and communication and helps foster collaboration and shared responsibility between scientists and society (Horst, 2022). Communication in science and technology involves exchanging information and ideas among scientists and between scientists and the public (Martín-Sempere et al., 2008). Regarding the definition, each country has its definition of science communication according to context, so there is no universally accepted definition of science communication (Schiele et al., 2021). Nevertheless, according to Gascoigne and Schiele (2020), science communication aims to inform, engage, persuade, change behaviors, and support better decision-making of the nation's people. The ultimate goal of science communication is to elevate the citizen's societal, environmental, and economic status. Moreover, science communication is vital for addressing issues within different contexts and regions, such as health, food and agriculture, and energy.

Science communication and society

According to Jucan and Jucan (2014), society relies on science to drive economic, social, and political progress, while science depends on society's resources, talents, capacities, and social freedom. Integrating science with social policy and concerns is crucial for building a secure, trust-based relationship. This integration helps bridge gaps in knowledge within the community.

Jucan and Jucan (2014) also highlight the need for scientific knowledge to play a crucial role in society, especially during crises like epidemics and economic downturns. Effective professional communication is essential; poor communication can undermine scientists' credibility and reduce research funding.

The scholar emphasizes science communication as one method of raising awareness. General dictionaries describe awareness as being aware while not neglecting anything. It was sufficient for general usage. However, there will be much more depth and implications if it is to explain the meaning of awareness in terms of the relationship between humans and science (Sykes, 1999). Gilbert et al. (1999) defined science awareness as "the perception of science as a collection of positive attitudes toward science and technology." The skills and behavior displayed can demonstrate scientific awareness.

Also, Burns et al. (2003) defined "science awareness" as "people's attitude toward science," which is considered necessary and serves as the foundation for leading "people's understanding of science" and "knowing science". Millar (1996) defined "understanding science" in three main aspects in the context of studying science: 1) understanding the contents or essence of scientific knowledge, 2) understanding the process of acquiring scientific knowledge, and 3) understanding the role of science as a social enterprise that has an impact on individuals and society.

The traditional approach to addressing the relationship between science and society, mainly when there is tension between science and society, involves efforts to increase public understanding of scientific discoveries and theories. Nevertheless, many individuals in the public already comprehend the fundamental scientific concepts and information. Then, they may not accept or hold different opinions about the presumed implications associated with such knowledge.

Thus, relying only on developing scientific knowledge may be inadequate. The consideration for addressing the science- society relationship has shifted toward interactive dialogue and open discussion to exchange knowledge and opinions about science and technology, called " Public Engagement" . Through active involvement, scientists and the general public discuss the benefits and risks of scientific and technological advancement that has impacted everyday living. Concerning active conversations, concerns from the public can be addressed and resolved. Moreover, with the active involvement of stakeholders with different interests, unrelated points of view can be interconnected, resulting in potentially profound consequences (The American Association for The Advancement of Science, 2023).

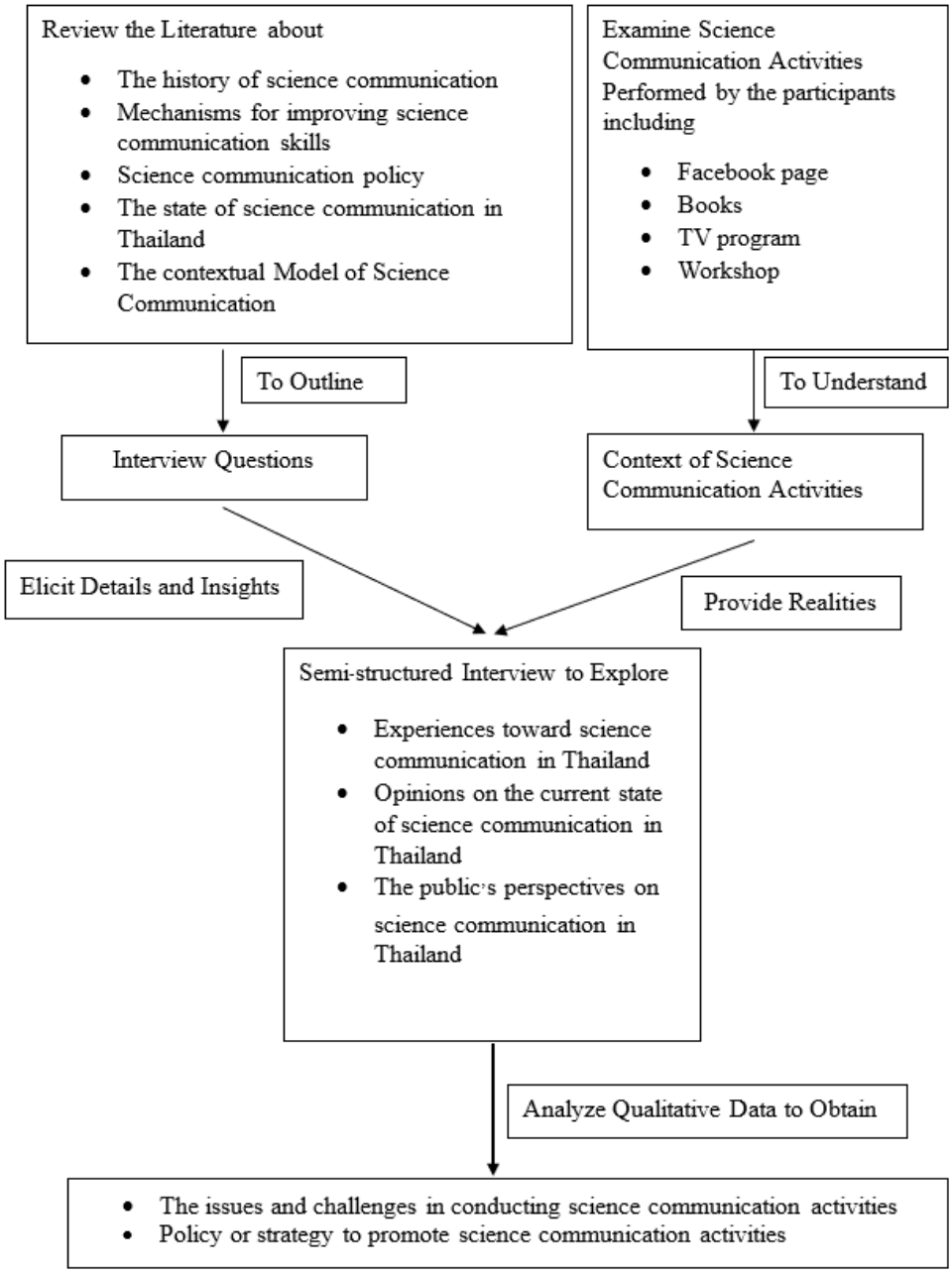

Figure1 The conceptual framework of this study

In the UK, the "Public Understanding of Science" concept has also shifted toward "Public Engagement of Science" and emphasizes it as an instrument of science policy. This alteration signifies a change from emphasizing scientific knowledge disparities between scientists and non-scientists to a more cooperative approach encompassing knowledge opinions from those two stakeholders incorporating with decision makers (Gregory & Lock, 2008). Examples of initiatives that emphasize "engagement" are the "UK Synthetic Biology Roadmap" and the "Nanotechnology Strategy Forum". It fosters public engagement and dialogue to rebuild trust between scientific endeavors, government institutions, and the general public (Jones, 2014). According to The American Association for The Advancement of Science (2024), citizen science is a public engagement initiative that emphasizes collaboration from members to engage in research to generate new knowledge (Monzón Alvarado et al., 2020). Many researchers employ citizen science to address societal issues (Stanifer et al., 2022; Craig et al., 2024).

The contextual model of science communication

This model is described by Lewenstein (2003) as "The contextual model (or models) acknowledges that individuals do not simply respond as empty containers to information but rather process information according to social and psychological schemas that have been shaped by their previous experiences" (p.3). Regarding this, cultural context and individual circumstances shape their interpretation of communicated scientific information. According to Lewenstein (2003), understanding diverse audiences' needs, attitudes, and existing knowledge is vital for effective science communication. Brossard and Lewenstein (2010) also emphasize the significance of context. They mention the experiences and situations of individuals, and culture influences cognitive interpretation based on social and psychological schema and how the individual responds to information. In addition, social forces in society and the setting for disseminating scientific knowledge are essential (Lewenstein, 2003).

According to Brossard (2015, as cited in National Research Council, 2015), adopting genetic modification technology is an example of a scientific issue in which culture plays an important role. Brossard mentioned that regulatory mechanisms to ensure the protection and safety of the cities are significant concerns in countries throughout Asia and Africa. On the other hand, European countries worry about the ownership of technology and the consequences of the technology at the production level, which is a local farmer. In addition, Brossard pointed out that other issues, including international trade, consumer choices, labeling, and food safety, are concerned with varying locations and cultural significance.

Iyengar and Massey (2018) address the cultural and political context influencing science communication. Regarding this, distrust in scientific institutions, partisan polarization, psychological biases, misinformation, and disinformation are cultural and psychological factors that exacerbate the public's ability to engage with scientific information, inevitably affecting science communication. Moreover, evaluating science communication efforts emphasizes the context. Fischhoff (2018) mentioned that effective science communication should focus on the context where science communication facilitates informed decision-making rather than promoting specific behaviors.

History of science and science communication in Thailand

Chen et al. (2020) suggested the Thai royal family significantly influenced science. During King Rama III's reign (1724-1850), Thai students first went to Europe to study science, marking Thailand's introduction to modern science in the 18th century. King Rama IV advanced technologies like the printing press, photography, the automobile, and astronomical equipment, though usage was limited to a few city dwellers. Modernization continued under King Rama V (1868-1910), with Western-educated royals introducing trains, ships, medicine, and architecture. Under King Rama IX (1946-2016), Thailand reintroduced science and emphasized science communication.

Modern science communication started in 2000 when the government prioritized science and technology. Academics and policymakers began using science communication principles, inviting international experts to speak at universities. By 2005, discussions on

public communication of scientific knowledge emerged. The National Science and Technology Development Agency (NSTDA) has since highlighted the media's role and scientists' participation in science communication (Chen et al., 2020).

Regarding government policies, the Ministry of Science and Technology's strategies included promoting public awareness of science. It is a critical strategy in the Ministry's action plan for 2004-2013 (National Science and Technology Development Agency, 2004). After restructuring government agencies, the National Science, Technology, and Innovation Policy Office (STI) has taken the lead in developing the national strategy. Science awareness and communication have become less critical under the STI's supervision and are now only a part of the action plan (Chen et al., 2020). The National Technology and Innovation Policy and Plan for 2012-2021 emphasizes increasing the country's competitiveness through research and development. There was preparation for Globalization's Changes by promoting social equality and security through investments in science infrastructure, research funding, and human resource development. However, science awareness and communication are only one aspect of human development and are less critical than ongoing education and capacity building (Chen et al., 2020). The Thailand 4.0 policy, announced by the government in 2015, aims to reform education and increase the need for participation of science-related agencies, including private-sector cooperation, to promote science and science learning. The announcement raises the demand for learning science at one's own pace and communicating science. Departments of science and educational institutions are increasingly responding to such demands. However, attracting the attention of young scientists remains challenging due to various factors, and additional government assistance in attracting and motivating those young scientists is required (Chen et al., 2020). Taking science communication as a career in Thailand is still in its early stages due to a need for clarity about the roles and importance of science communicators and the general public's lack of understanding of this occupation. People who work in science communication nowadays are either journalists or scientists. Furthermore, there are still many departments where the roles of science communicators and science educators must be clarified (Chen et al., 2020).

Participants and methods

The participants were five experienced scientists who carry out science communication activities, and their works are released to the public on more than one platform, for example, Facebook and book, and have experience in science communication activities for at least two years or have received an award related to science communication activities. In addition, the participants include two officers working as science communication specialists with more than 5 years of direct experience working in science communication. According to all selection criteria described earlier, the science communicators and the officers participating in this study are considered "experts" in science communication. In this regard, the researcher emphasized the communicator's point of view and also considered the receivers' opinions (Merriam, 1998). Therefore, the researcher included five public participants who received information through various forms of scientific communication or believed in information that scientific principles could not explain when investigating a public issue. Therefore, this study has twelve participants.

The researcher employed a semi-structured interview to investigate the difficulties and obstacles of communicating science in Thailand. To collect data on the science communicators and specialists participants' points of view, the researcher began to draft interview questions by reviewing the literature on the history of science communication, mechanisms for improving science communication skills, science communication policy, and the state of science communication in Thailand. The researcher then examined science communication activities performed by some of the science communicators' interviewees, e.g., Facebook pages, to understand the practical contexts of the science communication activities. As a result, the following semi-structured interview topics relate to the science communicators' and specialist participants' experiences and opinions on the current state of science communication in Thailand: What are the issues and challenges in conducting science communication activities in Thailand? What policy or strategy should Thailand implement to promote science communication activities?

With the emphasis on the contextual model of science communication, the interview topics have included the public's perspectives on science communication in Thailand. The following were interview topics: Why do people still believe in fake news or propaganda, and how can we improve the situation?

The interviews took place in person at a convenient location for the participants. The discussions were typically 45-60 minutes long and audio-recorded with the participant's permission. The audio recordings were then transcribed, evaluated by the participants to confirm the accuracy of the transcription processes, and qualitatively analyzed. The contextual model of science communication guided the data analysis, and the method used was inductive thematic analysis, which enables a researcher to uncover and organize patterns in content and meaning in qualitative data (Braun & Clarke, 2006; Willig, 2013). As a result, the method chosen can provide the researcher with an explanation for the situation described earlier.

During the study, the participant can freely leave it at their discretion. Moreover, the researcher keeps participants' personal information confidential, analyzes the data generally, and discloses no specific data.

Results

The researcher conducted semi-structured interviews with science communicators and officers working as science communication specialists. The analysis of the interview transcripts while considering the contexts of science communication activities revealed significant concerns, problems, and barriers to science communication. The researcher divides the factors that hampered scientific knowledge dissemination or science communication activities into three major themes. These themes are: (1) The negative impact of misapprehension about science, people's uncritical thinking, and perfunctory behaviors, (2) Insufficient administrative support, and (3) Inconsistency between the nature of science and the needs of audiences. Analysis of the interview transcripts also revealed the public participant's perspectives and opinions on the causes of rejecting science. The details of the analysis supported by illustrative quotes from the participants are as follows:

The negative impact of misapprehension about science, people's uncritical thinking, and perfunctory behaviors

According to the participants, people in society have erroneous perceptions of science because they believe it is difficult to understand; science is a complex subject accessible only to those with superior intelligence. This perception may cause people to refuse to comprehend scientific content. The following excerpt is an example of a conversation provided by participants:

"It is a field that anyone who studies science or even the teachers who teach science see as difficult. If you are not good enough, you should not choose to study science. (I think) it was wrong from then on." (Scientist)

"Our country may not yet see its importance (science communication) as it should. It may be seen as just conveying information, so it does not sound difficult. However, it seems difficult for most people to understand because it is scientific. It is perception. I think that when talking about science, people think it is not easy. Even though some things are actually not difficult, it cannot be denied that some scientific contents are not easy to understand because there are a lot of technical words. People must have a basic understanding of scientific content to understand it." (Science communication specialist)

Participants also mentioned people's beliefs, values, and attitudes, as they tend to believe without justification and avoid arguments. An example of the conversation reflecting this point of view is as follows:

"In Thai society, people tend to abide by others' beliefs without the courage to argue because they perceive it as misbehaving. (I think) science is not a matter of belief without using judgment, but science is a matter of debating." (Scientist)

This incident describes irrational acceptance that contradicts the nature of science, and it is yet another factor that the research participants identified as a barrier to conducting science communication activities. Social media, such as Facebook, also reveals the consequences of people's uncritical thinking when a scientist posts or comments to scientifically explain a phenomenon that contradicts certain beliefs. In such cases, that scientist is often publicly rebuked.

Insufficient administrative support

Many participants expressed concern that science communicators in Thailand have yet to receive sufficient government support regarding declarations relating to job descriptions and career promotion of science communicators. Furthermore, authorities have not sufficiently provided budgetary allocations for supporting systems and strategies to drive science communication and assist science communication activities. Examples of conversations regarding the concerns are as follows:

"There is no reinforcement or policy that explicitly indicates strategies for engaging the public and define expected outcomes from communicating science." (Scientist)

"I think there will be a problem with the budget and management, and it links with what I said—it is unclear about whose duty it is and who is a communicator. It is like doing it (science communication) with passion." (Science communication specialist)

The opinions of the abovementioned participants indicated the importance of government involvement, as science communications demand a variety of government support and initiatives.

Inconsistency between the nature of science and the needs of audiences

The participants' responses mentioned the nature of scientific knowledge, which is that an experiment or new research could create a new body of knowledge. Therefore, prior bodies of information can become outdated, so science communicators must provide current findings rather than draw firm conclusions about existing knowledge. This fact can help explain various phenomena; however, it differs from the needs of the audience, who want a conclusion without analyzing it themselves. An example of the conversation representing the participant's point of view is as follows:

"Sometimes, the knowledge we have at a certain point in time is correct. As time passed, new knowledge emerged and proved what we knew was wrong, such as about gastritis. We believed it was a non-communicable disease in the past, but now we know bacteria can cause it, and it becomes a contagious disease (when the bacteria cause it). If we say that gastritis is contagious, in the past, we have been laughed to death or sued to death. Therefore, many people (science communicators) try to speak in a neutral way (for example, it may cause this disease). The villagers do not appreciate this. They like to hear only the fixed conclusion." (Scientist)

The abovementioned research participants' perspectives reveal some significant issues and barriers that cause people to lack knowledge and understanding of science.

Participants also shared their thoughts on the following strategies for preventing and solving problems in science communication:

1) Develop young people's critical thinking and reasoning abilities. Furthermore, inquiry-based learning is required to heighten young people's interest in science and promote science communication.

"It is necessary to instill a culture of knowledge and knowledge inquiry in our young people since they were kids by taking them to places like this (a science center or museum) and letting them see how these places will benefit them. It will become their belief and habit" (Science communication specialist)

"Young people need to learn how to think logically over time, and I think it would be best to start with an adolescent and build on that." (Science communication specialist)

2) Increase access to scientific knowledge through establishing collaboration with foreign countries in developing science communication and using social media to increase access to scientific knowledge.

"So we talked about a short course, about how we can develop it (science communication techniques) into a short course for scientists or the public. Yesterday, our staff contacted universities in the UK to discuss this issue…. We should establish a connection with them. In our country, there is a trend that when doing a short course like this, collaborating with a foreign organization will be more interesting and attractive. It will be difficult if you do it yourself (without collaboration)." (Science communication specialist)

"If you want to create small projects (to communicate science) and make them widespread

nationwide, use social media to make them (disseminate the projects) work the most." (Scientist)

3) Create science communication platforms/associations to serve as a gathering place for science communicators to gather and organize science communication activities that will help bolster people's interest in society.

"You can create a project that connects science communicators as partners and creates content (together)." (Scientist)

"But I think it will be good if we provide a platform for them (science communicators)." (Science communication specialist)

The public participants offered solutions to problems that impede science communication and discussed how science communicators promote knowledge and understanding of science and raise awareness of the importance of science through science communication. These two examples of conversations below reflect that promoting critical thinking and understanding that science is constantly evolving can help people avoid premature judgment based on incomplete information. In addition, the government's mitigations that force companies to indicate supplements' ingredients and hold them responsible for false claims are important factors in building trust in science, which helps facilitate science communication.

"For choosing to consume information is the same (as communicating with her students), maybe I want to share (on Facebook). However, I should control my mind and not judge if I do not have enough information or do not know what happened before. How can I say that (is true)? We should not think that what we think is always factual." (Public participant)

"I think they (government authorities) must be strict with the company (who sells food supplements or dietary pills). There is nothing to do with the media because it has come out in large amounts, and most teenagers are interested in (the media), so the company makes products and uses the media to convince them to buy. The media plays a role in influencing young people to consume it (harmful products)". (Public participant)

There is one suggestion mentioned is allowing people to access information according to their beliefs. Then, letting them compare the verified and unproven information from a wide variety of sources could better solve the problems.

"To solve this issue, allowing people to get more information, both what they believe in and what they should take which is already proven and let them make a comparison by their own" (Public participant)

Furthermore, the public participants expressed or commented on the problems and causes of rejecting science, which results in difficulties communicating science. The public's points of view reflecting important considerations are as follows:

1) People need more scientific knowledge to make scientific decisions or distinguish between science and pseudoscience.

" It is like most people do not know if it is counterfeit medicine. They just know that this is the FDA approved. They do not check if it is counterfeit or not unless they really have the knowledge. " (Public participant)

2) People are unwilling to inquire about scientific knowledge because of the nature of the knowledge.

" People rarely read things that are said to be trustworthy because they are difficult to understand. Sometimes you must read to the end to understand it, but (some) Thais do not read that much anyway. " (Public participant)

3) People who believe in irrational information, fake news, or propaganda usually account for their preference, which is unlogical and mistrustful information, rather than considering the information's reliability and validity.

" I think the reason probably comes from individual needs. He (a person whom interviewee addressed) really wanted to get to that point (where he achieves his desire) that he did not care about anything anymore and lack of appropriate knowledge in choosing

to consume things that are safe for himself" (Public participant)

4) There is much unfiltered and unauthenticated information on the internet. As a result, raising awareness among people to verify the information before consuming it is critical.

"I think there is no one seriously monitoring this (misinformation). Is this information that spreads across the internet right or wrong or good? Sometimes, a person just shares it without screening. Sometimes, I see someone having breakfast; they eat only bananas and boiled eggs, which is very little. I have been to the comments, too. If you eat like this, you will lose weight, but your metabolism will be destroyed. I think people must be conscious. Sometimes, people want to share a post on their (Facebook) wall. People saw the post and just wanted to share it. They are just going to save it for viewing later by sharing on their (Facebook) wall, but others may be able to follow along" (Public participant)

Discussion

According to the analysis of the interview results, one factor mentioned from the perspective of science communicators and the public is some people's belief that it is not scientific-based principles. There is a tendency to believe in it without analyzing its credibility, avoiding conflicts, and rejecting or not using scientific reasoning and evidence in disputes. According to Hornsey (2020), the rejection and non-acceptance of science have their roots in cognitive psychology, which includes:

1) Ideologies, as discussed in the theory of Cultural Recognition by Kahan et al. (2011), state that individuals' acceptance of science depends partly on whether scientific conclusions align with their beliefs. Climate change exemplifies this notion. However, claims that "conservatives distrust science" or "conservatives oppose science" are overgeneralized. Ideology in the context of trust requires more specific measures of views about different types of science, such as production science and impact science (McCright et al., 2013).

2) Rejecting science due to vested interests involves individuals and organizations that would incur costs if they accepted the science; for example, coal miners may reject climate science because it threatens their jobs, or organizations may spread false information to protect their interests (Hornsey, 2020).

3) Some groups reject science due to a conspiracist worldview, accepting unofficial information over evidence from government agencies (Hornsey, 2020).

4) Fear and phobias: Fear often outweighs reason, and people tend to find reasons to justify their concerns (Haidt, 2001).

5) Personal Identity Expression: People's views on science often reflect their identity and uniqueness; for example, a "Proud Nonconformist" may reject societal norms or scientific beliefs to communicate their independent thoughts and opinions (Hornsey, 2020).

6) Social identity needs: Anti-scientific views can be associated with belonging to a social group with beliefs contradicting scientific conclusions. This "social identity" impacts thoughts and feelings about science, especially if someone is unfamiliar with the topic (Earle, 2010; National Academies of Sciences Engineering and Medicine, 2016).

Regarding the responses from the public participants in which some people depend on irrational information, fake news, or propaganda, human cognition's nature would explain these misjudgments. With such cognition, humans attempt to simplify complex or ambiguous scientific information, which may lead to the rejection or acceptance of pseudoscience. People often use shortcuts to reduce the mental effort in evaluating evidence and making decisions about information, often based on personal experience (heuristics). These shortcuts can be adaptable and enable individuals to make quick decisions about the impact or harm of the information under consideration (Tversky & Kahneman, 1974). However, these shortcuts can misinterpret scientific content, primarily when uncertainty exists (De Bruin et al., 2007). The tendency of individuals to focus on information that aligns with their current feelings and knowledge demonstrates the influence of heuristics on understanding, memory, and decision-making (National Academies of Sciences Engineering and Medicine, 2017).

Furthermore, people tend to selectively attend to and believe the information they frequently encounter is more accurate or essential than information they meet less regularly, even if that belief needs to be corrected

(Fazio et al., 2015). Several researchers also explained that there is a tendency for individuals outside the scientific community to use idiosyncratic explanations for various events and rely on analogies and metaphors in their conclusions. They tend to emphasize content or perspectives unrelated to the events (Chi et al., 1981; Bostrom, 2008; Downs et al., 2008). Lazer et al. (2018) have suggested interventions that aim to reduce the impact of fake news. The first intervention is to allow individuals to perform fact- checking and improve critical information skills through education. The second intervention is providing safeguards for filtering out fake news.

Another heuristic that humans use to influence their understanding and perception of scientific information is emotional factors. In general, emotions are tools to detect potential benefits and risks. Furthermore, emotional responses motivate people to act and assist them in considering important risk information (Slovic et al., 2004). Emotions also influence how people respond to and comprehend scientific information. This state of mind indirectly explains that rejection of science results from people's belief that science is difficult to understand. Emotional responses can help people focus on important information and decide the risks and benefits of different options (Evans et al., 2015). On the other hand, emotions can cause bias in understanding scientific information, leading to resistance and rejection of science or belief in pseudoscience. Emotions can also lead to the manipulation and limitation of responses to scientific information and, in some cases, a preference for harmful content over positive content (Shaffer & Zikmund-Fisher, 2013).

Another reason for science's rejection and non-acceptance is motivated reasoning, a heuristic humans use to evaluate and decide whether to believe the information. Motivated reasoning is "the systematic processing of information in a manner consistent with one's prior attitudes and beliefs, resulting in the formation of attitudes and beliefs that are resistant to change" (Lodge & Taber, 2013). As a result, information management techniques form in the brain. People prone to motivated thinking are more likely to reject truth, evidence, and observations that contradict their ideas. People employ this type of bias when evaluating information and making decisions. These people are more likely to reject facts and evidence contradicting their preconceptions and be skeptical of information contradicting their beliefs. This type of bias could be a source of irrational argumentation that contradicts the nature of science and a barrier to conducting science communication activities, as mentioned in the response from the science communicator participant. Because of this tendency, ways to communicate scientific information can influence how people perceive and interpret data, affecting their beliefs and attitudes toward the information (Kraft et al., 2015). In this regard, antagonizing people's psychological beliefs would be a time- consuming task that would necessitate a tremendous amount of effort. Making science more relevant, accessible, and entertaining would be a more practical way to improve science communication.

The Contextual Model of Science Communication (Lewenstein, 2003) supports the results of this study because the model suggests that the context of society, culture, and education influences an individual's motivation to accept or reject scientific information. Therefore, values, beliefs, and personal experiences should be the primary considerations in making people understand and accept science. Suppose an individual's context does not promote logic in thinking; in that case, that person may be more likely to use incorrect reasons or avoid logical thinking. The Contextual Model of Science Communication (Lewenstein, 2003) can explain and relate well to the behavior of receiving misinformation because it emphasizes that science communication does not depend solely on information. Instead, it is influenced by the recipient's social context, culture, emotions, and motivations. Therefore, designing effective science communication should adapt to the context of the audience and encourage more analytical thinking instead of focusing on just providing scientific information.

Psychological factors and social context cause people to share or believe information without checking, as those two factors are mentioned in the Contextual Model of Science Communication (Lewenstein, 2003). People often share information received from someone close to them without checking because they trust their friends. People who feel that science is irrelevant to one's life will not be interested in examining information or seeking additional knowledge. Science

communicators should design communications that encourage people to ask questions rather than provide information.

Responses from the public participants point out a need for people in society to acquire more scientific knowledge to make scientific decisions or distinguish between science and pseudoscience. This notion indicates an urgency to emphasize science education in a society where some people do not like seeking knowledge and lack analysis and reasoning. Science communication and science education aim to improve people's ability to make decisions about complex issues through assessment and reasoning (Beniermann et al., 2021). As a result, promoting the advancement of science education will benefit science communication.

According to Baram-Tsabari and Osborne (2015), despite some research claiming that arguing is a fundamental skill for reasoning and scientific inquiry, these skills connect science education and science communication. A scientific argument in social settings differs from a typical scientific argument in that the scientific argument in social settings includes ethical considerations. This situation becomes complicated because these considerations frequently involve moral or value-based judgments distinct from the scientific facts and evidence presented. It could lead to conflicts and disagreements within society and the scientific community. Therefore, scientific argumentation in social settings requires high reasoning skills. Despite these challenges, several studies have shown that reasoning, a part of the scientific argument in scientific-related social issues, can develop students' ability to argue and understand science. The researchers have demonstrated that reasoning in scientific argumentation can improve students' critical thinking and scientific literacy skills. Overall, those in charge of the country's advancement should emphasize encouraging young people to employ logic and scientific argumentation through science education (Zohar & Nemet, 2002; Khishfe, 2014; Sjöström & Eilks, 2018; Beniermann et al., 2021; Jafari & Meisert, 2021). Developing reasoning skills would be a strategy that, corresponding to public participant comments, helps raise awareness among people to verify the information before consuming it. Furthermore, studying science can help students understand the nature of science and scientific processes.

Many countries have policies encouraging effective public communication regarding science that affects well-being. These initiatives aim to improve public understanding, transparency, and engagement between scientists and the public, promoting trust and effective dissemination of scientific information. In France, a policy encourages collaboration between scientists and science journalists to improve access to credible information and address the misuse of scientific results. The French government has established Science Media Centers (SMCs) in several countries to support this, providing accurate information and facilitating dialogue among scientists, journalists, and the public. In 2005, the SMC organized a meeting for scientists and journalists to discuss societal issues, and it has since raised funds from various sources (Pain, 2020).

Governments can also foster collaboration in science communication by establishing strategies to build strong networks among involved parties (Sugiono & Salamah, 2019). The 2004 Science Korea Movement is an exemplary model, demonstrating active participation from the government, scientific communities, universities, industries, media, and NGOs (Sook-Kyoung, 2012). Pinto et al. (2017) suggest increasing national-level training opportunities in science communication to raise public interest in scientific outreach.

Recently, the government's support for science communication in Thailand has increased. The government organization that plays a key role is the National Science Museum (NSM). Regarding this, the NSM supports and collaborates with government and public agencies in many science communication-related events, such as the Science Communication Festival or the Young Thai Science Ambassador (YTSA) project (National Science Museum of Thailand, 2023a; 2023b). As part of its commitment to promoting science communication, the NSM has formally established a Science Communication Division within the National Center for Public Awareness of Science. The establishment of the division suggests a path for career promotion in science communication (National Science Museum of Thailand, 2024). In addition, there is a private organization called the "Science Communicator Association," whose members include scientists or people interested in science. This organization was recently established in 2023 and became a co-host of the

first science communication festival in 2023 in collaboration with the NSM, several organizations, and other government agencies (Faculty of Science, 2023). The attempts of the Thai government to encourage an arrangement of science communication activities demonstrated a promising future in science communication and public understanding of science. However, changes in science and technology policy, when political changes emerge, could be an issue since different cabinets might affect the continuation of the ongoing policy.

Hackling et al. (2001) argue that promoting scientific literacy should be a primary educational goal, emphasizing the importance of increasing public interest and understanding of science. Such goals include making science relevant to everyday life, encouraging critical thinking, evaluating scientific content, and making informed decisions about consumption and environmental choices. Priest (2013) calls this "Critical Science Literacy," which considers scientific knowledge and social dimensions to engage individuals in scientific discourse and informed decision-making.

Conclusion

According to the literature and interview analysis, science communication in Thai society has increased since 2000, driven by scientists and policy-making units. This growth has led to a higher demand for science communicators, with various organizations and educational institutions responding. However, challenges remain, such as the invisibility of some science topics, the complex and evolving nature of scientific knowledge, and content that contradicts the audience's preference for accessible summaries. Although there has been increased government support for science communication, only a limited number of agencies are actively involved.

The educational system is also a root cause of these challenges. It fails to promote understanding of the benefits and importance of scientific knowledge in daily life and does not encourage scientific thinking skills. This results in a lack of scientific knowledge for informed decision-making. Moreover, the public perceives science as distant and unrelated, partly due to media and marketing strategies discouraging critical thinking and reasoning.

To address these issues, laws or guidelines should be enacted to reduce the burden on science communicators and enhance public access to scientific information. Recommendations include:

1. Make science engaging and relevant to daily life by improving public perception of science, making it more relatable and valuable. The strategy includes making science accessible and engaging through various mediums, such as hands-on activities and citizen science projects, and providing practical science communication training to scientists.

2. Foster collaboration among scientists, communicators, and public relations professionals. The strategy includes establishing workshops, conferences, or forums for shared dialogue and joint projects among scientists, communicators, educators, policymakers, and the public.

3. Create accessible science learning centers nationwide. The strategy includes establishing public-private partnerships to leverage resources and expertise from both sectors to gain more grants and tax deductions for their development and operation.

4. Increase government involvement in promoting science communication. The strategy includes the government developing policy initiatives that prioritize scientific literacy and fund public engagement, such as integrating science communication training into educational curricula.

5. Make the public perceive scientists as effective communicators. The strategy includes encouraging scientists to actively participate in public outreach activities and share their work through accessible platforms such as social media.

6. Provide incentives for science communicators. The strategy includes offering grants and fellowships specifically for public engagement projects to the science communicator or scientists, showing recognition, and rewarding outstanding contributions through awards or prizes.

7. Implement mechanisms to filter and verify scientific content online. The strategy includes encouraging the public to use fact-checking websites and tools to verify claims and identify potential misinformation.

8. Promote research in science communication and public understanding. The strategy includes establishing research units and academic programs focused on

science communication and facilitating collaborations between communication scholars, scientists, and public engagement practitioners.

This study aims to understand the obstacles hindering science communication in Thailand from the perspectives of science communicators and specialists. Despite the small sample size, the findings can help frame further in-depth study for a larger group of science communicators. The contextual model of science communication becomes a framework for designing interventions or strategies to overcome the barriers, leading to more relevant and practical science communication practice. Therefore, the further studies emphasizing the contextual model of science communication could lead to more innovative tools and strategic recommendations for advancing science communication in Thailand and similar countries.

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