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The Role of Nuklear Malaysia as a Hybrid Organisation to Promote Science Culture: A Study Using Triple Helix Model

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ABSTRACT

This research paper investigates the Malaysian Nuclear Agency's (Nuklear Malaysia) role as a Hybrid Organisation in promoting a scientific culture to help Malaysia achieve its vision of becoming a developed, high-income nation. The analysis focuses on two primary activities led by Nuklear Malaysia as a key agency in nuclear science and technology: (1) education and training and (2) technology transfer to industry stakeholders. The Malaysian Government's initiative to leverage nuclear science and technology for social and economic development is supported by international entities such as the International Atomic Energy Agency (IAEA). The IAEA Technical Cooperation Programme has significantly contributed to Malaysia's national infrastructure development, particularly in human capital development. Through this Programme, Malaysia received assistance through fellowships, scientific visits, training, meetings, workshops, provision of experts, and procurement of equipment, which provided a strong foundation for Malaysia to continue sustaining the peaceful uses of nuclear science and technology in national socio-economic development. This paper examines the activities related to promoting science and technology transfer, emphasizing their impact on strengthening the role of science in enhancing the nation's social and economic landscape. For this study, the modified Triple Helix Model is used to interpret the relationship by substituting the role of academia with public research institutions due to their similar functions in fostering science and technology for industrial development. Thus, the model demonstrates how Nuklear Malaysia, as a hybrid organisation, can expand the application of nuclear science and technology for social and economic progress by advancing sectors such as medicine, manufacturing, environment, agriculture, and oil and gas through its scientific innovations. Furthermore, as a hybrid organisation, Nuklear Malaysia plays a crucial role in translating government policies into actionable strategies for relevant industries.

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INTRODUCTION

Science and civilisation are intertwined social components that contribute significantly to society's and the economy's development, stability, and sustainability. Many believe the earliest civilisation began in the Tigris-Euphrates valley, known as Mesopotamia, where cities like Sumer and Babylon emerged. This region is notable for the invention of the wheel, initially used by potters and later by armies for transportation. The Mesopotamian civilisation, particularly the Sumerians, made significant advancements in astronomy; by the 2nd millennium BCE, they had created star catalogs, identified the Zodiac, and utilised a 12-month solar calendar alongside a 354-day lunar calendar. By the 3rd millennium BCE, they regularly used a 360-day calendar. The Babylonians recorded a solar eclipse as early as 763 BCE and developed instruments to detect the appearance of stars and planets in the south. Medicine and surgery also advanced in Mesopotamia, with practices such as tooth filling, and the profession of physicians gained recognition (Beg, 2008). These achievements were driven by scientific developments, particularly in mathematics, physics, and chemistry. Social analysts note that science studies emerged as a significant cultural area within anthropology in the 1990s (Franklin, 1995).

Understanding the definition of culture and science

Historically, science has played a vital role in society and the economy. Integrating science into society as part of its culture is crucial. In sociology, culture includes the languages, customs, beliefs, rules, arts, knowledge, and collective identities developed by social groups, making their environments meaningful. This is studied through communication expressed in narratives, ideologies, practices, values, norms, and social classifications (American Sociological Association, n.d.). There is no single definition of culture; for instance, Kroeber and Kluckhohn identified 164 definitions in 1952 (Spencer-Oatey, 2012). Edward Tylor defined culture as 'that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society' (Spencer-Oatey, 2012). This definition laid the foundation for modern definitions of culture.

Feibleman (1948) defined science through three groups: field, science, and laws. The field's ontological postulates include the existence of natural phenomena, their uniformities and non-uniformities, and levels of analysis. Science's postulates involve the possibility of operating on a field with instruments, discovering laws as a process, and progressing toward more inclusive theories. Laws' postulates include probable laws expressed statistically, causal laws mathematically, and constants in nature. Feibleman (1948) described science as a cultural division that searches among facts, through hypothesis, experiment, and verification, for laws and causes, leading to event prediction and control, ultimately involving mathematically formulated theories. The U.K. Science Council defines science as 'the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence' (The Science Council, 2019). Sociologists view science studies as part of broader changes challenging the scientific establishment (Franklin, 1995).

Malaysia's standpoint towards science culture

Science and technology are recognised as essential investments for facing 21st-century challenges and building a strong, innovative economy (MASTIC, 2018). Modern society heavily relies on technology for transportation, healthcare, food production, education, and communication, thanks to advancements in physics, mathematics, and engineering over the past century. Public exposure to and appreciation of science are crucial for improving quality of life (Farrona & Vilar, 2016).

Malaysia is transitioning into a knowledge-based economy with a strong focus on science and technology as key drivers to achieve its aspiration of becoming a developed nation by 2025. This ambition is aligned with Vision 2025, a continuation of Vision 2020, highlighting the critical need to harness science and technology for economic progress and to foster knowledge-intensive industries. Indeed, the country's

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economy has witnessed significant advancements in scientific and technological activities where education holds a pivotal role, particularly in promoting science among the younger generation to cultivate a knowledge-driven society (Azizan, 2013).

Malaysia has implemented policies such as the National Science, Technology, and Innovation Policy and the Mega Science Framework Study for Sustained National Development (2010-2050) to promote science and technology. Various educational programmes, including the Malaysia Education Blueprint initiated in 2011, aim to attract youth to STEM fields, supporting the country's aspiration to become a self-sufficient, industrialized nation with economic prosperity, social well-being, and world-class education. Malaysia has recently introduced the National Nuclear Technology Policy (NNTP) 2030, demonstrating the Government's commitment to advancing the peaceful use of nuclear technology for economic growth, knowledge development, and societal well-being.

Understanding Theories and Perspective of Nuclear Science and Technology for the Economy's Growth

This study will explore nuclear science and technology as a knowledge domain that significantly contributes to national economic growth. Historically, knowledge has been vital for human adaptation and progress. About three decades ago, knowledge became central in discussions about a new social system distinct from industrialisation and its predecessors. López-Leyva et al. (2014) assert that this new system hinges on the direct link between technological knowledge and economic and social growth resulting from its application (López-Leyva et al., 2014). However, this paper focuses on the role of technology as a conduit for knowledge in this emerging social system, underscoring the importance of a knowledge-based economy.

A knowledge-based economy is characterized by the creation, assimilation, transfer, and use of knowledge by enterprises, organisations, and communities, which drive economic growth (Chen & Dahlman, 2005). Chen and Dahlman (2006) present a holistic knowledge economy framework that includes education and training, innovation and technological adoption, information infrastructure, and a supportive economic incentive and institutional regime. They argue that sustained investments in these components are crucial for the effective utilization of knowledge to boost economic growth. This framework suggests that such investments enable the creation, adoption, adaptation, and use of knowledge in domestic economic production, leading to higher value-added goods and services. This, in turn, increases the likelihood of economic success and development in the competitive global economy (Chen and Dahlman., 2005). When science and technology are integrated into the economy, technology transfer becomes essential, facilitating the application of scientific knowledge to economic activities.

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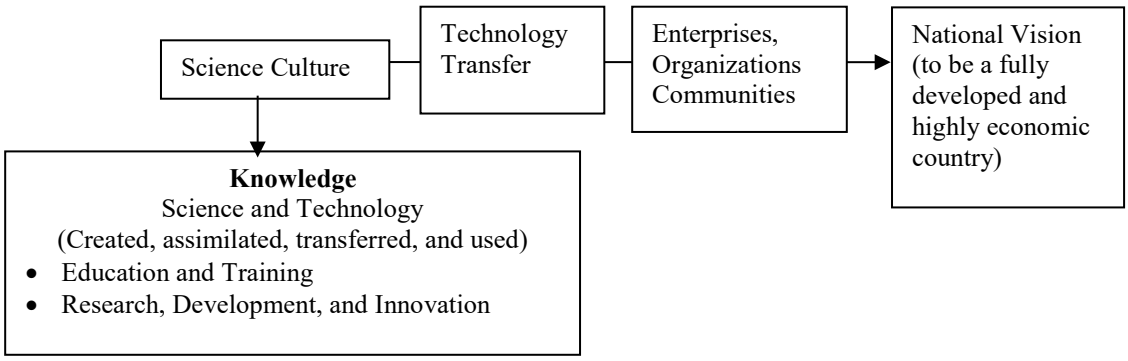

Fig. 1. Relationship between Science Culture and National Vision

Using the Triple Helix Model, this paper examines nuclear science and technology's impact on national economic growth. This model, developed by Leydesdorff and Etzkowitz, highlights the collaborative roles of universities, industries, and governments in fostering innovation and economic development (Abd Razak & White, 2015).

In this context, Nuklear Malaysia functions similarly to a university, engaging in education, research, and technology promotion. As a hybrid organisation, it generates new formats for producing, transferring, and applying nuclear knowledge, bridging the gap between government and industry.

The adapted Triple Helix Model underscores the importance of policies and strategies in nuclear science and technology, which guide Malaysia's economic growth. For instance, the National Science and Technology Policy (NSTP) aims to leverage S&T for economic development, aligning with strategies to enhance manufacturing and attract high-tech investments (Ministry of International Trade and Industry, 2018). To foster a science culture, Nuklear Malaysia supports government policies through education, training, outreach programmes, and technology transfer to relevant industries and communities. For instance, Nuklear Malaysia actively engages in the Researcher Industrial Scientific Exchange (RISE) Programme, which facilitates expertise sharing between researchers from the Ministry of Science, Technology and Innovation (MOSTI) and industry, enhancing product innovation and productivity. This study, however, focuses on education, training, and outreach programmes as key strategies to promote a national science culture.

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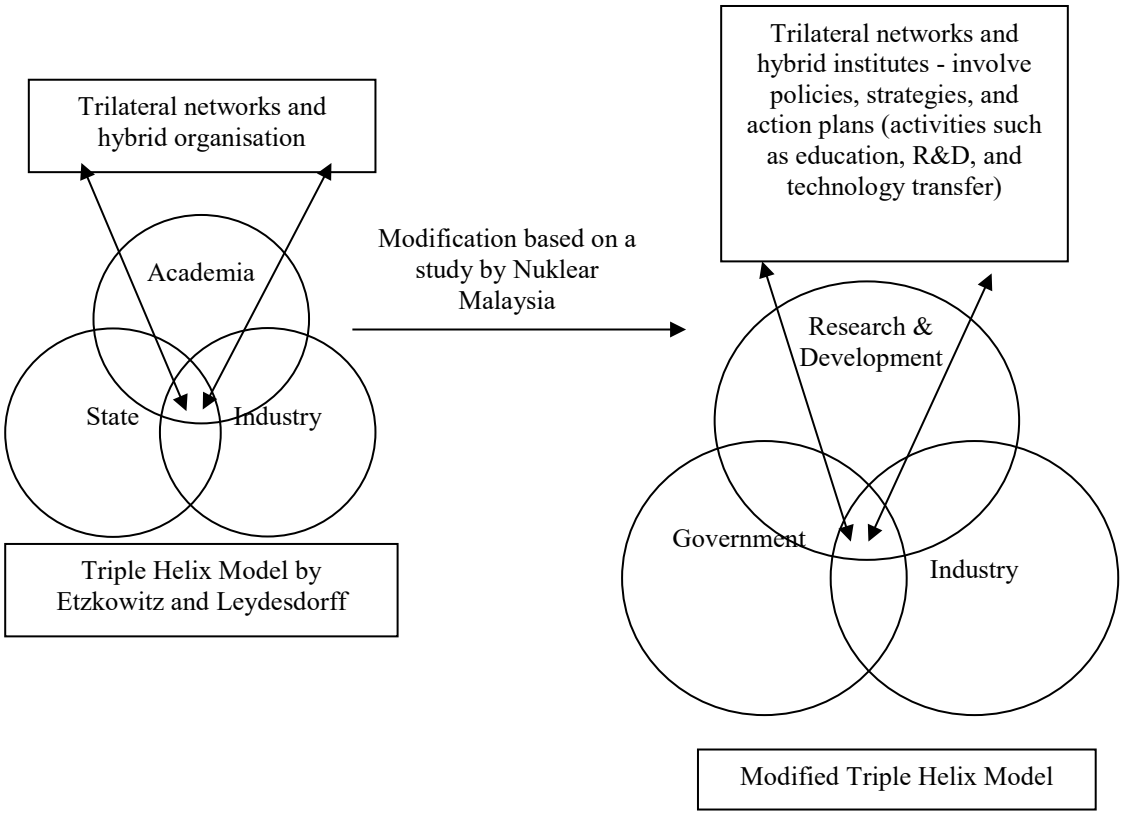

Fig. 2. Comparison between the Triple Helix Model introduced by Leydesdorff and Etzkowitz in 1997 and the modified Triple Helix Model based on this study

The Role of the Malaysian Nuclear Agency

As the premier public research and development institute in nuclear science and technology, Nuklear Malaysia has played an important role in cultivating interest in nuclear science and technology among Malaysians. Related activities were deliberated and aligned with the Government's policies and functions of Nuklear Malaysia, which is responsible for conducting research and development (R&D), services, and training in the field of nuclear technology for national development, and for promoting the use, transfer, and commercialisation of nuclear technology. However, this paper only focussed on outreach, education, and training as part of activities to cultivate science culture and promote nuclear science and technology to industries as catalysts to the national economy.

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METHODOLOGY

A methodology used for this research is the case study method. This method focuses on one particular case in more detail (Thomas, 2014). The case study selected should represent a significant issue/issue and must have an adequate fact base to make possible reasonable conclusions, even if it does not directly state any conclusions. Ellet (2007) suggests that when carrying out a case study analysis, the researcher must be able to:

- Construct conclusions based on the information given in the text;
- Filter out irrelevant or less important facts/data of the text;
- Furnish missing information through cross-reference/ inferences and
- Combine evidence from different parts of the case and incorporate it into a conclusion.

Nuklear Malaysia was chosen based on several characteristics, such as the nature of this organisation, which is a prominent research institute in nuclear science and technology in Malaysia. Based on the Triple Helix Model, this paper discusses the overlapped sector, which is the trilateral network between Government, academia, and industry, and how Nuklear Malaysia plays a role as a hybrid organisation for nurturing nuclear science and technology in Malaysia and as part of a national effort toward fostering science culture among its citizen (Jerome & Jordan, 2024). This relationship is shown in Figure 3.

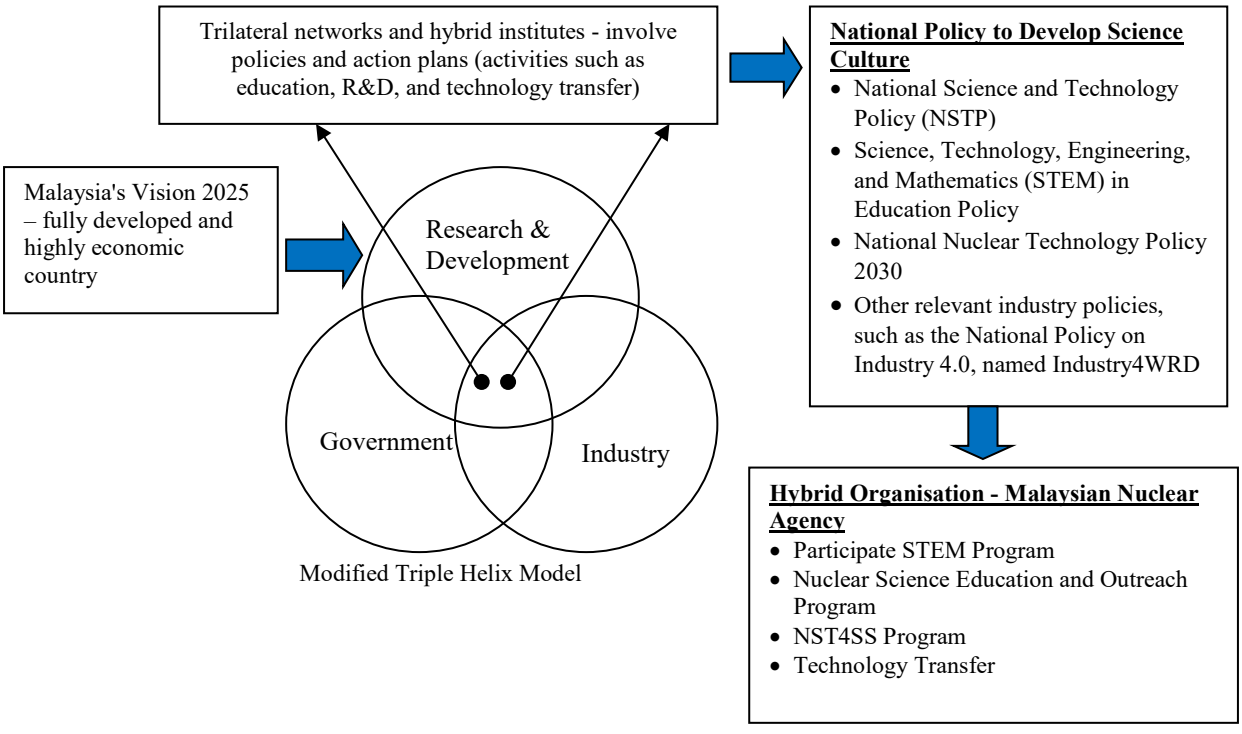

Fig. 3. Relationship between Malaysia's Vision 2025, the Triple Helix Model, and the Malaysian Nuclear Agency to support national insight of becoming a fully developed and highly economic country by 2025

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ANALYSIS AND DISCUSSION

The Government always makes huge efforts to help industries through science and technology. For example, MOSTI has outlined several initiatives, namely:

i. Policy on R&D Fund, which 50% of the MOSTI R&D Fund will go to industrial-based research.

ii. The RISE Programme is a platform for sharing the expertise of researchers from MOSTI to industry to increase innovation and productivity of the industry as well as capacity building for both sides (MyGOV, 2024).

iii. Knowledge Exchange for Science and Technology Excellence. Through this programme, industries are permitted to use the Government's scientific infrastructure, including instruments and machines. This programme also allows them to use data from the MOSTI Open Data.

iv. Commercialisation of technology by strengthening five technopreneurship funding agencies under MOSTI, which are the Cradle Fund, Malaysia Venture Capital (MAVCAP), Malaysia Debt Ventures Berhad (MDV), Kumpulan Modal Perdana and Malaysian Technology Development Corporation (MTDC).

As a primary research institute in nuclear science and technology for this country, Nuklear Malaysia is responsible for translating government policies into action plans and supporting relevant industries to intensify their production, which directly helps national society and the economy. To highlight nuclear science as part of the economy's booster, various activities and tremendous efforts are being put into motion to win public sentiment regarding the use of nuclear technology. Amongst these are public and media awareness programmes, in which general information on nuclear science and technology is disclosed, disseminated, and explained to the public, provided it does not pertain to sensitive information (Sahar et al., 2017). Key targets are students and the young generation, which are primary groups that cultivate interest in science. Such programmes will also help to raise public confidence and support for nuclear science and technology. Nuklear Malaysia acknowledges the need for viable and effective education and outreach programmes to nurture public trust and confidence in nuclear science and technology. Besides the education and outreach programme, this paper also scrutinised how other activities accomplished by Nuklear Malaysia could support the national economy through its innovation and technology transfer activities. This paper deliberates on activities by Nuklear Malaysia as a contributor to the science culture and how Nuklear Malaysia acts as a hybrid organisation based on the Triple Helix Model.

Nuclear outreach and education programme (Nuclear Education Outreach (NEO) Programme

An outreach programme can be defined as a programme that is commonly conducted to reach the public and disseminate information to influence and persuade other's opinions so it may turn favorable. (Sahar et al., 2017). Comprehended by the status quo of nuclear science and technology among Malaysians, which is undesirable because of the famous history – the Hiroshima and Nagasaki bombings and the Chernobyl disaster, Nuklear Malaysia has conducted several education and outreach programmes targeting various levels of generation and community. The importance of outreach programmes, especially for nuclear science and technology, is because nuclear posing a dual purpose, namely peaceful and non-peaceful, which often leads to serious public concern (Adnan, 2012). Therefore, these programmes were designed and created based on the 5W+1H question, namely what, who, which, when, why, and how. In 2010, Nuklear Malaysia carried out a programme called 'Siri Jelajah Malaysia 2010' "I Love Nuclear". This programme indicated that the public is still not fully understanding and acquainted with the roles of nuclear science and technology, especially in their daily life. However, the results of this programme show that 85% of people are in favor of nuclear technology, and 7% reject nuclear technology. Others decided to be neutral. The

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report of this programme suggested that Nuklear Malaysia needs to conduct more outreach programmes to educate the public on nuclear technology and its application. In addition, the report also points out that such an outreach programme needs to be designed explicitly for a specific target; for example, an outreach programme for professionals such as people in industries is different from a programme for school or college students (Sahar et al., 2017).

Along with outreach programmes, education is also an imperative segment to ensure that information is fittingly disseminated to the target group, especially schools, colleges, universities, and industries (Cukierman et al., 2016). One of the oldest outreaches programmes organised by Nuklear Malaysia was the Talk and Exhibition Programme for Secondary Schools, in which researchers from Nuklear Malaysia visited the school and delivered a talk related to nuclear science and technology as well as conducted a mini exhibition of R&D products and services offered by the agency. The programme was held from the 1980s till 2012, and later, in 2015, it was rebranded with new content injections and renamed Nuclear Science and Technology for Secondary School (NST4SSSome major improvements are the introduction of a new engagement module from the Japan Atomic Energy Agency (JAEA). Under the programme, the IAEA has invited several nuclear power countries that have implemented various outreach activities to share their experiences and expertise. These were converted into a compilation of modules, which can then be implemented by other countries. This compilation of modules is called the 'Compendium of Resources and Activities for Teachers and Students. Concerning this, the IAEA has invited Malaysia to become a pilot country together with three other countries, Indonesia, the Philippines, and the United Arab Emirates (UAE), to observe the effectiveness of this compendium. This invitation is seen as a recognition to Malaysia by the IAEA because Malaysia is very active in conducting outreach programmes to promote nuclear technology to the public, teachers, and school students. This pilot programme has demonstrated positive feedback from participants, both teachers and students.

A survey was conducted, and 100 teachers participated in it in 2015 from Selangor (West Coast of Peninsular Malaysia) and Sabah (East Malaysia). The survey showed that 90% agreed that the syllabus related to nuclear science and technology is important and should be emphasized in the classroom. While 5% felt that it was not important, 5% of participants were uncertain about it. In addition, 98% viewed that the existing syllabus related to nuclear science and technology needs to be expanded from various aspects to ensure information to students is accurate, aligned with the global development of nuclear technology, and up to date (Agensi Nuklear Malaysia, 2015). Later, in 2016, another survey was conducted among 100 participants under the same programme, but it was conducted in a different region of Malaysia. This time, the survey was conducted among teachers from Terengganu (East Coast of Peninsular Malaysia) and Sarawak (East Malaysia). The survey demonstrated increasingly positive feedback, with 98% agreeing that the syllabus related to nuclear science and technology is important and should be emphasized in the classroom. However, when asked about the need for improvement to the current nuclear science syllabus, 57% agreed that the syllabus needs some improvement, 22% did not agree, and 21% were uncertain about it (Ngadiron & Adnan, 2016). Although there was a slight decrease, the majority agreed that it needed improvement.

Nuklear Malaysia is also actively involved with education programmes developed by the Government to increase the young generation's interest in science. For instance, the Government launched STEM For All (STEM4ALL) in 2019. This initiative by the Ministry of Education (MoE) will implement three policy shifts in science, technology, engineering, and mathematics (STEM). Various discussions and collaborations between Nuklear Malaysia and other stakeholders such as MoE, MOSTI, IAEA, and NGOs are ongoing to promote nuclear science and technology. Efforts are made to ensure that nuclear knowledge is integrated into the national science syllabus, continuous professional developments for science teachers, and some basic laboratory facilities available for student's learning activities,

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Besides focusing on education and outreach programmes, Nuklear Malaysia is also involved in national and international exhibitions organized by schools, Government, and private sectors, and it uses this as a platform to promote and disseminate information about nuclear science and technology. Nuklear Malaysia also extended its expertise and technical information to the development of the I-Rays Gallery in the National Science Centre (PSN), which offers educational activities and exhibits related to nuclear science to the public. This method has proven to be a great opportunity to show and provide information about science to the public. This idea was quoted by Caulton in 1998, "the growth of hands-on museums and science centers has been one of the most remarkable features of the leisure industry in the last decade, with almost every new exhibition proposal today incorporating an interactive element for visitors"(Farrona & Vilar, 2016). Exhibitions are also recognised as objects of knowledge (Kaniari, 2014).

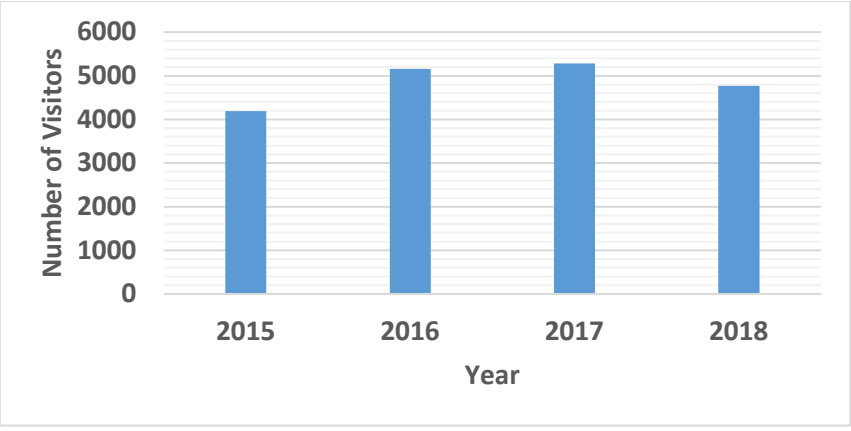

Fig. 4. Number of visitors to Nuklear Malaysia from 2015-2018 (Report of the 2018 Nuklear Malaysia Annual Performance Review Workshop- unpublished)

Still, there are some challenges in promoting nuclear science and technology, including but not limited to (1) lack of financial support, (2) lack of interest among the public in nuclear education, (3) ineffective communication/promotion channels, and (4) the terms/words been used to deliver the message was too difficult for people to understand (Sahar et al., 2017). However, although facing some challenges in promoting nuclear science and technology in Malaysia, continuous efforts partaken by Nuklear Malaysia have a positive influence on the national public awareness and perception of nuclear science. This is illustrated by the increase in visitors to Nuklear Malaysia. Figure 4 shows the number of visitors to Nuklear Malaysia from 2015 to 2017 increased approximately by 14%. Although in 2018, it decreased slightly by approximately 10%, it is still higher than in 2015 (Bahagian Perancangan dan Hubungan Antarabangsa, 2018).

CONCLUSION

There is no doubt that science plays a crucial role in boosting the economy. As a U.S. Senator once stated, "Whenever I meet with industry, they tell me that supporting university-based research is the single most important thing that we could do to bolster U.S. competitiveness" (Mervis, 2005). Consequently, many countries, including the U.S., invest heavily in research and development (R&D). This investment advances science, fosters new ideas, develops technologies, and leads to new products, services, and processes, thereby contributing to the successful evolution of the innovation economy (Wu, 2018).

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The relationships between science, technology, and society (with the economy playing a pivotal role) are increasingly stronger and more prevalent today. The growing awareness of the importance of a science culture in society is reflected in the social movement known as "Scientific and Technological Literacy (STL)." Gerard Fourez, a social scientist, argued in 1997 that just as literacy was essential for integration into industrialized society in the last century, today's society requires knowledge of science and technology to fully participate in the modern world (Fourez, 1997).

Aligned with this view, Malaysia, like other nations, has developed numerous agendas and programmes to cultivate a scientific culture among its people. These agendas are implemented through various institutions, with Nuklear Malaysia being a key government tool. Through the Triple Helix Model, Nuklear Malaysia can strategize to increase public interest in science culture, particularly in nuclear science and technology. The Triple Helix Model emphasizes the importance of cooperation between the Government, academia, and industry in promoting science as a tool for economic and social well-being.

A significant challenge for Nuklear Malaysia is the pervasive negative sentiment towards nuclear science and technology, a global issue even in countries with active nuclear power programmes. This paper demonstrates that one strategy to develop and encourage a science culture among the public and to amplify the national economy is through education and training campaigns. These can be executed via outreach programmes, edu communication, and the formulation of policies such as science, education, and industry policies. Continuous efforts and promotion by Nuklear Malaysia have shown that there is a strong interest in nuclear science and technology when the public understands the benefits of its peaceful applications.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest related to this study. No financial or personal relationships with other people or organisations could inappropriately influence this work. All funding sources for the research were disclosed, and there were no financial or non-financial conflicts that could be perceived as influencing the results or interpretation of the study.

AUTHORS' CONTRIBUTIONS

Bashillah Baharuddin designed and conceptualised the central research idea, developed the theoretical framework, and anchored the review process. She also revised and approved the final submission of the article. Mohd Hafizal Yusof, Siti Syarina Mat Sali, and Habibah Adnan contributed to revising the paper and updating the data and information to reflect the current situation as of 2024.

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