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Strengthening Scientific Literacy on Polar Regions Through Education, Outreach and Communication (EOC)

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ABSTRACT

In the 21st century, mankind must acknowledge the roles of polar regions in global sustainability, especially its interrelationship with Earth's climate system. Notably, dissemination of science knowledge and awareness that arises through education, outreach, and effective communication are key instruments that can help towards environmental conservation and sustainability on the polar regions. This paper aims to discover the science knowledge that has been derived about the polar regions and then to recommend the comprehensive approach for strengthening the Education, Outreach and Communication (EOC) strategy in promoting the polar regions. The fundamental scientific literacy on the polar regions can create a new understanding and respect towards the polar regions by mankind. Specifically, this would happen when a scientific perspective is brought into global problems that integrate socio-scientific issues (SSI) in science education and fostering science diplomacy and global common. Besides, it broadens the perspective about the earth as a global ecosystem. Therefore, a synergy framework of EOC is needed in a national polar programme to strengthen and sustain the public's awareness and interest on the polar regions. Consequently, the information from this paper is important for policy makers and national polar governance in developing the future strategy of co-ordinating stakeholders and funds for EOC initiatives, especially during the Year of Polar Prediction (YOPP).

KEYWORDS
Antarctic, arctic, environmental education, education for sustainability development

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Introduction

Over the last decade, there have been growing concerns over the environmental issues in the polar regions. The concerns are about human activities that have contributed towards climate changes that are affecting the

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polar regions and rest of the world. The Earth's polar regions (Antarctic and Arctic regions) are crucial for regulating the world climate, but they are vulnerable to the impacts of global warming. The connection between increasing polar temperatures, ice volume loss, and sea level rise, and these changes started relatively slowly because of the immense inertias in the climate system in the oceans and polar regions. Ricci and Egerton (2010) highlighted that the two regions can provide an insight into fundamental Earth system processes that are of crucial importance for the environment and climate of the Earth as a whole. However, it is the location where these important processes originate that can provide an early warning of climatic changes. Undoubtedly, changes in the polar regions are important at the global level as they have far-reaching effects on the atmospheric and ocean circulation (Azzolini et al., 2012). Therefore, with the multitude of current sustainability challenges facing the polar regions such as climate change and global warming, many countries have taken actions to conserve these regions through science diplomacy as discussed by Berkman et al. (2011) and Berkman and Vylegzhanin (2013).

Scientific research and effective governance are important for the conservation and sustainability of the polar regions. However, education, outreach and communication (EOC) strategy have also been recognised as an essential part of national polar research programme to improve the appreciation, science knowledge and awareness of the public towards this region. Dayer et al. (2008) stated that traditionally, education, outreach, and communication were aimed at changing knowledge, skills, attitudes, or behaviours of an individual or group of people. Hence, the social component in the conservation related issues of the polar regions may necessitate EOC activities targeting specific groups of people. Therefore, messages appropriate for different audiences must be created to encourage and promote direct conservation outcomes. Environmental education, awareness and communication are key processes that enable participation, increase capacity building and solicit actions for sustainable development (Lotz-Sisitka, 2003). Madsen (1996) explained that environmental awareness, knowledge, and commitment are necessary to achieve environmental protection and restoration, while the public must have a basic understanding of the environment.

EOC efforts on the polar regions must be given an equal standing to research, besides an important role within polar scientific programmes to ensure that key audiences, especially educators (school teachers and lecturers), students (at schools and universities) and the media have the resources and networks to access relevant and current science information. Harrison et al. (2009) highlighted that there is a growing need to improve links between scientists and society because science plays an important role in people's lives and because humans are significantly (and increasingly) affecting the environment. Barbour et al. (2008) pointed that beyond the growing desire for more contact with relevant science projects, there is an increasing recognition that science literacy is a critical component in promoting public awareness of science advancements and current events, such as climate change, to help the public make decisions based on scientific findings. Therefore, EOC initiatives can serve as a medium for increasing awareness and understanding about the polar regions and for delivering information and publicity about the national agenda in the polar regions.

Polar scientific research does not involve much participation from the public, especially for most equator-latitude countries. Therefore, the public will lack the knowledge about the importance and the role of polar science. Consequently, this will create negative perceptions of this involvement. In fact, Baron (2010) highlighted that in general, the public has little knowledge of science, while some have even become sceptical of science, leading to disenchantment and cynicism. However, the influence of science on the society is determined by the level of development of science on the one hand, and by the extent of public understanding of science on the other (Kaixun, 1999). According Lubchenco (1998) and Baron (2010) in Provencher et al. (2011), as science becomes more pervasive in daily life and decision making, it will then be widely recognized that science can no longer afford to be conducted behind closed doors and away from the public eye; therefore, scientists need to make communication a priority. Ricci and Egerton (2010) stated that there is an increasing need to extract important and validated results from national polar programmes to transfer advice to policy makers. The significant values must then be provided to the broader public and to politicians as a justification for the financial investments that are required to sustain these efforts. Undoubtedly, it is through the popularisation of science that all scientific achievements in the polar regions involvements have produced an enormous impact on the society.

Nature of Science Knowledge on Polar Regions

Why does the public need to know about the polar regions' ecosystem? What knowledge is generated through scientific research on polar regions? What does the public know about the ways in which scientists do their work in this coldest region? How can the public use the results of the polar scientific research to meet current and future challenges to their country region and societies? These are among some of frequent questions that have been raised over why people from around the world need to be concerned about this coldest region, especially for those who live in far away and equator-latitude countries. In answering these questions, the Intergovernmental Panel on Climate Change Report 2007 (Chapter 15) highlighted that the polar regions are the key to the global ecosystem and barometers of the health of the planet. These are the places where global processes connect across the earth; and these regions are increasingly recognised as being (i) geopolitically and economically important, (ii) extremely vulnerable to current and projected climate change, and (iii) the regions with the greatest potential to affect global climate and thus human populations and biodiversity.

Therefore, scientific literacy on the polar regions is highly important to strengthen the knowledge and understanding of scientific concepts and processes and scientific activities on polar regions. Consequently, it is expected to contribute significantly to knowledge on the global sustainability debate.

The Organisation for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) defines scientific literacy as the capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. In the context of the polar regions, scientific literacy may relate to the ability of the world's citizens to think scientifically and to use scientific knowledge and processes from polar research to understand the interconnection of the polar regions with earth's system, and to participate in decisions that affect this region.

Corrigan et al. (2010) highlighted that scientific literacy is important for both intrinsic and instrumental justifications. Intrinsic justification refers to cultural aspects, meaning that scientific knowledge can help people to satisfy their curiosity about the natural world, which is also very important in learning (Howes, 2002). On the other hand, instrumental justification refers to the utilitarian aspects, meaning that scientific knowledge is necessary as a foundation for making informed practical decisions about everyday matters, participating in decision making in science-related issues, including working in science and technology related jobs (Millar, 1996). Notably, both of these justifications are consistent with the polar science content applied in context, because this content may provide learners with the knowledge required in socio-scientific decision making and may satisfy their curiosity about the earth pole regions.

Environmental issues of the polar regions have been of strong concern over the years, together with global warming, climate change, and pollutions. Global warming has become the key word that describes the environmental issues and problems concerning this region. The accelerated ice melt in the polar regions is expected to affect sea level rise and global circulation patterns significantly. Azzolini et al. (2012) stated that the changes in ocean currents, temperature conditions, ice cover and reduction of permafrost regions will have impacts on marine and terrestrial ecosystems, causing changes on the range of species distribution and migration patterns. Meanwhile, Ricci and Egerton (2010) stressed that the high costs of infrastructure or environmental protection and other direct economic impacts of climate change show that understanding changes occurring in polar regions is highly relevant to the lives of people. Thus, the polar regions have a central role to play in helping the general public to understand the interconnection of the region with climate change, global warming, ice melting and sea level rise, and how it could trigger a domino effect to the global ecosystem.

Besides, the Students on Ice Alumni Association has published a paper on the sustainable development challenges and opportunities in the polar regions, entitled "Navigating from Rio+20 to Polar Sustainability: Solutions for Sustainable Development in the Arctic and Antarctic." The paper explained the importance of, and threats to, the polar regions, and identified gaps in the zero draft of the outcome document of the UN Conference on Sustainable Development (UNCSD, or Rio+20), relating to the polar regions. To address these gaps, the paper recommended four actions as follows: (i) Recognise the importance of the polar regions as an emerging challenge in the context of sustainable development, (ii) Strive for carbon neutrality in Antarctica, (iii) Recognise the rights of indigenous peoples in the context of sustainable Arctic resource development, and (vi) Commit to protecting polar oceans to protect global oceans.

Winther (2014) stated that the scientific information from the polar regions boosts people's knowledge of the environmental issues facing the world and is vital to grasp the challenges facing people, be it climate change, sea level rise or pollutants. Concurrently, Beck et al. (2014) highlighted that the polar regions continue to spark people's curiosity and imagination, with a sense of adventure and fear of the unknown, providing the perfect ingredients for education as well as public outreach. In addition, their scientific importance, extraordinary beauty and adventurous history provide the perfect ingredients for both education and public outreach. The study of polar exploration is fascinating and offers students

insights into the history, culture, and politics that affect the developing sciences at the farthest ends of the earth (Renee & James, 2009). Meanwhile, Pfirman et al. (2004) identified ways to provide leverage to the importance and excitement of polar science, starting with what people think they know about polar organisms – and then moving beyond the charismatic mega fauna of polar bears, penguins and whales to look at the diversity of adaptations to life in extreme environments.

Socio-scientific Issues (SSI) are controversial social issues relating to science and they are ill-structured, open-ended problems that have multiple solutions (Sadler, 2004; Zeidler & Keefer, 2003). Thus, SSI are utilised in science education to promote scientific literacy, which emphasises the ability to implement scientific and moral reasoning to real-world situations. Some examples of SSI relating to the polar regions include issues such as climate change, global warming, ice-melting, mining of natural resources, and ozone layers. Research by Zeidler and Sadler (2008) has shown that SSI is effective in increasing students' understanding of science in various contexts, argumentation skills, empathy, and moral reasoning. Facione (2007) argued that SSI can; (i) cultivate scientifically literate citizens who are able to apply evidence-based scientific content knowledge to real-world socio-scientific scenarios; (ii) foster a collective social conscience whereby students consistently reflect upon the formation and implications of their own reasoning; (iii) encourage argumentation skills that are essential for thinking and reasoning processes and mirror the types of discourse utilised in real-world scientific deliberations; and (vi) promote critical thinking skills, such as analysis, inference, explanation, evaluation, interpretation, and self-regulation.

According to Burek (2012), the real-world problems used within curriculum embedded with SSI are multidimensional and promote critical thinking because they go deeper than just science into cultural, political and economic spheres, engaging students in moral and ethical discussions. Students need to recognize that the more clearly they can articulate their positions on socio-scientific issues, the better prepared they are to take on the decision-making process. Thus, no doubt will influence their livelihood and the health of the community in the future (Chowning, 2009, as cited in Burek, 2012).

In the context of polar regions and SSI, the educators utilise SSI to foster understanding the content of polar science and the consequences on everyday scientific issues. For example, in studying polar ice-melting, a student may consider whether the ice-melting in the polar regions caused by global warming only affects those regions or other regions as well. This type of analysis would require students to research the interactions between polar regions in terms of global warming, weather, and ocean system, as well as the socio-economic impacts of this phenomenon. Students could make evidence-based decisions and discuss this issue through various means including whole-class discussions, online discussion boards, debates, and so forth. The goal of discussing SSI in the polar regions is to provide students with the knowledge and skills for making decisions about the crucial polar issues such as climate change, global warming and rise of sea level and to ensure the sustainability of polar regions. The use of socio-scientific issues of polar regions allows students to examine more closely the links between morals and ethics as parts of scientific knowledge. This knowledge may ultimately lead to the goal of scientific literacy, which requires critical thinking skills.

Science is a common feature of human activities, whether in the polar regions or elsewhere on earth and beyond. Furthermore, the polar regions also provide the public with the key knowledge and understanding on international scientific cooperation and science diplomacy. Mutual assistance, cooperation in emergencies and free exchange of scientific information are key aspects of the way researchers are working worldwide and applying them in the polar regions. Notably, the Arctic Council has established a task force for enhancing Scientific Cooperation in the Arctic (SCTF) and the articles of the Antarctic Treaty System (ATS) also highlighted the importance of scientific cooperation in ensuring the sustainability of this region. Meanwhile, through science diplomacy, the public will learn how to integrate science with the social location or situation to foster a paradigm of territorial expansion, resource acquisition, temporary settlement, nationalistic claims, and political expansion created by encounters. Fedoroff (2009) highlighted that the science diplomacy is the use of scientific collaborations among nations to address the common problems facing humanity in the 21st century and to build constructive international partnerships. The Royal Society and the American Association for the Advancement of Science (AAAS) have suggested the three dimensions of science diplomacy as follows. First is science in diplomacy, meaning providing scientific advice for foreign policy objectives. Second is diplomacy for science, which means facilitating science cooperation. Third is using science cooperation to improve international relations between countries, also known as science for diplomacy.

Science diplomacy and polar regions education can comprise a wide range of subjects, from broad themes to specific topics in ensuring that these regions are used for science and peace. Certain science-related international relations issues, such as research station, bio-prospective and vessel/ice-breaker topics, are well covered. More recently, tourism pollution, and other natural resource issues have also received attention. Given the pervasive nature of polar science, topics and resources can and should also be integrated and directed at the more general audience. The polar regions are good examples to stimulate discussion about science diplomacy as an evolving approach to promote cooperation and prevent conflict in this world. Thus, connecting these two key elements with scientific literacy on the polar regions may contribute to an interactive learning process in the school and university classrooms.

Polar regions may provide an excellent way to transmit basic concepts and knowledge about a wide range of disciplines such as science, technology, social science and humanities, including the concepts of socio-scientific issues and science diplomacy. The concept and knowledge from scientific literacy on the polar regions are in line with the global agenda of Education for Sustainable Development (ESD). According to Csobod (2002), ESD is similar to education for the environment; nevertheless it also involves issues of human rights, social environment, global inequality and conflict. Values in the scientific literacy of polar regions include the epistemic values of science (the values of science itself), societal values and the personal values of scientists. The scientific literacy of polar regions has raised the global need for environmental citizenship and it is a form of citizenship that prioritizes and emphasizes the importance of the polar regions' environment and crosses national boundaries. Furthermore, encouraging lifelong scientific literacy of the polar regions is important because it can create an appreciation for science and nature by connecting science and society early in life.

Later, these connections may be reinforced through varied education, outreach and communication strategy.

EOC Efforts on the Polar Regions

The catalyst of EOC efforts on polar regions came during the fourth International Polar Year (IPY) 2007–2008 and during the IPY EOC. The IPY 2007–2008 represented one of the largest international scientific research efforts ever undertaken after 125 years following first IPY (1881 to 1884). According to Provencher et al. (2011), the fourth IPY was the largest and most comprehensive international science programme on the polar regions. Tens of thousands of scientists, and more than 14 million people in 70 countries were touched by outreach events. The goals of the fourth IPY were to make major advances in polar knowledge, to stimulate new and enhanced observational systems and infrastructure, and to inspire a new generation of polar scientists and engineers (Salmon et al., 2011).

The IPY subcommittee and its national counterparts provided a tremendous stimulus for increasing awareness and understanding on the roles and issues of the polar regions. The following is summary of International Polar Year 2007–2008. Part Four consisted of IPY Public Programmes; Publishing and Archiving IPY; New Generation of Polar Scientists; it defined EOC as follows:

- **Education** refers to efforts designed to promote the development of programmes, infrastructure and resources needed to improve knowledge of polar-focused science, technology and humanities. These formal educational efforts occur mainly within classrooms. Formal education is not necessarily limited to curricula, but ranges from teacher training to classroom science experiments.
- **Outreach**, sometimes called informal education, refers to experiences for learning outside of formal classroom environments through stimulating media, exhibits and community-based programmes. Examples of outreach activities include field trips, museum exhibits, zoo exhibits, lecture series, computer software, school competitions, quizzes, and essay writing.
- **Communication** identifies interactions with the print, television, radio, Internet, and film media.

IPY EOC stimulated active engagement of thousands of teachers, students, and citizens around the globe through international collaboration and cooperation, careful cultivation of global community of enthusiastic professional science communicators and educators, and creative use of free technologies (Carlson, 2010). Meanwhile, Goessling (2015) highlighted the goals of EOC during IPY (2007-2008) as a legacy of enhanced observations, interest and participation of "non-scientist," advanced polar knowledge and new generation of polar scientists. Provencher et al. (2011) mentioned that through the integration of science outreach from budget to results, dedication of outreach personnel and an inclusive approach to all aspects of science outreach. Thus, IPY has demonstrated that the public wants to be engaged in polar issues, and how science can incorporate good science and effective outreach. Provencher and team added that this type of public engagement is not only critical for science literacy, but also is the level of involvement in science that helps to keep science in the forefront in

the people's minds. Thus, it is high on the agenda of governments and organizations funding research.

Pfirman et al. (2004) stated that to be effective, education and outreach infrastructure must (i) have a dynamic, sustained, one-stop polar research and education web site as a central resource for content and contacts for all ages, (ii) have strong supportive partnerships that evolve into a polar learning community with dynamic ongoing communication and collaboration among agencies, scientists, educators, media, northern peoples, students, communities, different countries, and the general public, building on existing programmes and networks and incorporating modern technologies, field experiences and innovative teaching methods, (iii) ensure that the long-term involvement of educators and scientists goes beyond the conclusion of the IPY, to sustain polar science and education at the mainstream, and (vi) develop research, education and outreach programmes that are truly international and link communities around the globe through common interests.

The many lessons learned from the IPY EOC efforts can help inspire science efforts to improve planning, enhance self-evaluation and expand on the current elevated interest in public education, outreach and communication programmes. It is clear that the success of polar science programme derives in part from close connection between science and advance strategy in EOC. IPY EOC provides a tremendous catalyst for an action plan, which called for a high-impact global campaign to increase awareness on the polar regions, targeted at key sectors with key messages.

Year of Polar Prediction (YOPP) and Synergy Framework in EOC of Polar Regions

Year of Polar Prediction (YOPP) is a key activity of the World Meteorological Organization/World Weather Research Programme Polar Prediction Project (PPP) that encompasses three different phases: a preparatory phase (2013 to mid-2017), the main YOPP period (mid-2017 to mid-2019), and a consolidation phase (mid-2019 to 2022). The YOPP aimed to improve significantly the environmental prediction capabilities for the polar regions and beyond, by co-ordinating a period of intensive observation, modelling, prediction, verification, user-engagement and educational activities. To achieve the goals of the YOPP will require innovative international polar research, which will be crucial for the success of the project. This will stimulate new and next generation scientists become interested educated in polar prediction. YOPP can be seen as a legacy project of the International Polar Year (IPY), however in contrast to IPY, YOPP is much more focused on the prediction problem on daily to seasonal time scales (YOPP, 2015). To meet the growing demand for skilful and reliable predictions in polar regions and beyond, eight key research goals were identified and six strategies were designed to achieve the YOPP goals (see Figure 1).

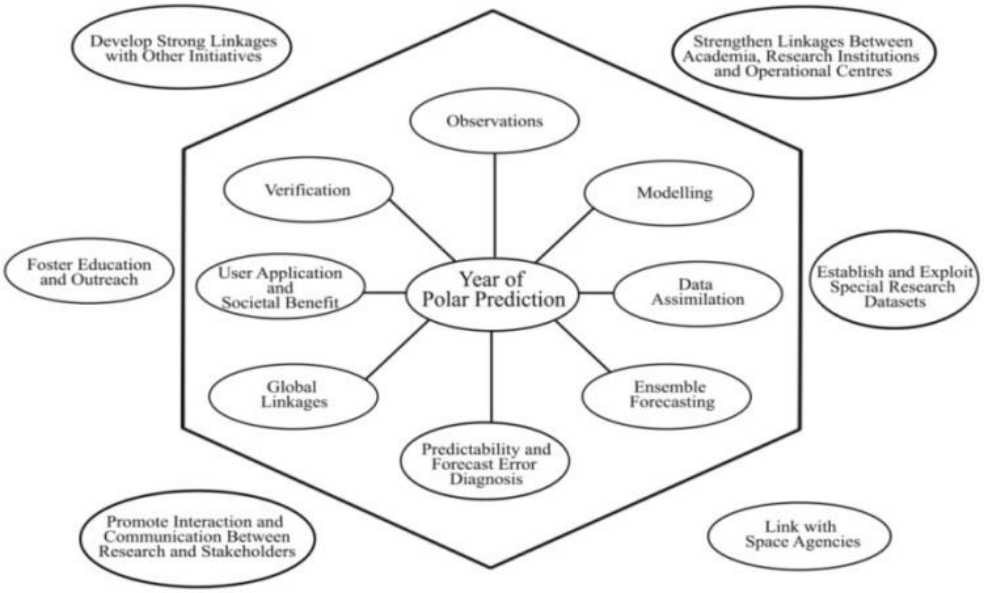

Figure 1. Goals and strategies of Year of Polar Prediction. Adapted from Year of Polar Prediction, 2015.

Like IPY, the success of YOPP derives in part from close connection between science and EOC. Foster EOC is a part of the key strategies that will be crucial for the success of the YOPP goals to stimulate interest and educate new and next generation scientists in polar prediction. World Meteorological Organization (2014) stated that YOPP will provide many early career scientists, including postgraduate students and postdocs, with the opportunity to actively participate in an event that is expected to significantly advance polar research in general, and polar prediction in particular. YOPP-EOC programme will create and deliver information and resources to the general public, government and private agencies, the broader academia community, university and school students, corporate sectors, and the media.

To achieve the goals of EOC-YOPP and support its strategic plan, every nation involved in the polar regions needs the strategic plan that involves the commitment and synergy of multi-stakeholder at the international and national level with the following objectives: (i) To ensure that science knowledge, appreciation and awareness of the public on the polar regions are sustained, (ii) To boost national funds for outreach, education and communication on the polar regions, and (iii) To encourage the participation of various stakeholders at the national level in the YOPP.

Figure 2 shows the proposed synergy framework of EOC, which involves participation of various stakeholders, from the public to the private sectors at the national level. The framework that involves the commitment and synergy of various stakeholders, particularly at the national level aims to (i) ensure that public appreciation and interest on the polar regions are sustained, (ii) boost the national funds for outreach, education and communication on polar regions, and (iii) encourage the participation of the various stakeholders at the national level

in the Year of Polar Prediction (YOPP). Tantalo and Priem (2014) stated that "stakeholder synergy" perspective identifies new value opportunities creation that are especially effective strategically because a single strategic action increases different types of value for two or more essential stakeholder groups simultaneously, and maintains the value already received by any other essential stakeholder groups.

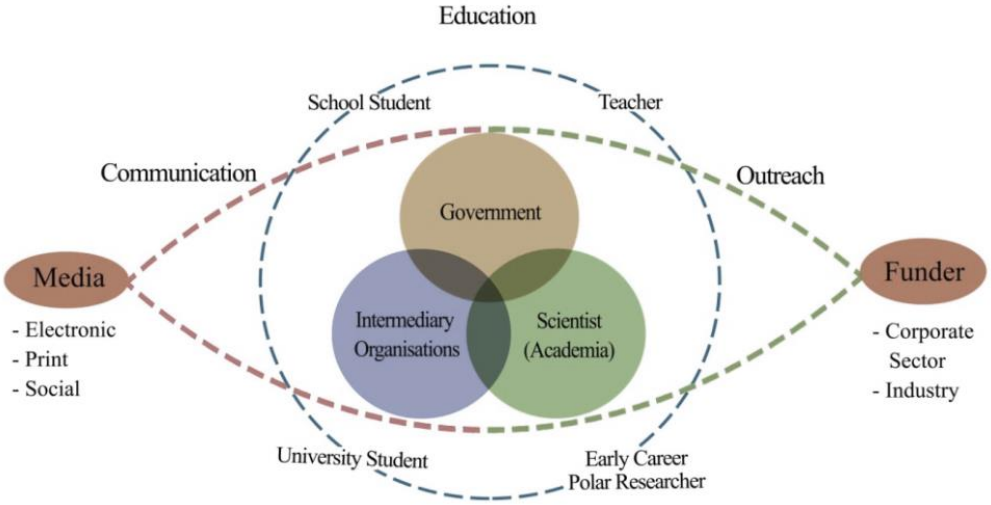

Figure 2. Synergy framework of education, outreach and communication (EOC)

In modifying the previous IPY-EOC strategy, authors suggest that the framework stands on one simple key message, that is, polar regions in Global Sustainability is subdivided into four main priorities, namely (i) climate change and global warming - rapid change in the polar regions ecosystem, (ii) interactions and linkages between the poles and the rest of the Earth, (iii) ecological footprint and human impacts on the polar regions, and (vi) science diplomacy, science heritage, and culture of the polar regions. Meanwhile, the synergy of multi-stakeholder will provide the significant impacts as follows: (i) To foster clear awareness of, and concern about environment, economic, social, and political interdependence in polar regions, (ii) To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the ecosystem of the polar regions, and (iii) To create new patterns of behaviour in individuals, groups and society in the world as a whole, towards the protection and conservation of the polar regions.

The framework highlights the integration of three institutional spheres, which consist of government, intermediary organisation and scientists (academia) that serve as a base to ensure the success of YOPP-EOC. The engagement of countries in the polar regions, especially in the development of polar science programme requires political support, participation, funding and co-operation from their respective governments. Country governments need to be able to anticipate the rising demand for important of knowledge and involvement of countries on polar regions. Governments play a key role to stabilise interactions

in the economic and social networks that enable the system to ensure cooperation, partnership and institutional support (Farinha & Ferreira, 2013). Government and its related ministries have their own interests in integrating elements of the polar regions into national education policy and environmental education strategy. However, their presence in the national mechanism comes with their own implications. The relevant ministries directly involved with the national polar agenda are the nodal agency in the administrative structure of the central government for the planning, the promotion, the co-ordination and the overseeing the implementation of their national polar policies and programmes.

Thus, in the context of EOC, the relevant ministries play crucial roles in (i) developing educational and teaching materials and teaching aids on the polar regions for the formal education sector, (ii) encouraging NFOs, media, and other concerned organisations for promoting awareness on the polar regions among the citizens at all levels, (iii) promoting polar regions education through existing educational and scientific research institutions, (vi) ensuring training and manpower development in polar regions education, and (v) mobilising awareness of citizens in the preservation and conservation of polar regions environment. In the context of polar governance in Malaysia, the Ministry involved directly in Malaysia's agenda in the polar regions that provides relevant policies on polar region at national level is the Ministry of Science, Technology and Innovation (MOSTI). Therefore, MOSTI needs to work together with the Ministry of Education and Ministry of Higher Education to achieve, support and encourage the national initiatives in YOPP-EOC at the primary, secondary and tertiary level.

In this model, intermediary organisations refer to the institutions or agencies that act as a task force on the National Polar Programme. Kivimaa (2014) highlighted the role of intermediary organisations in enacting change in socio-technical regimes, particularly of intermediaries falling between traditional public sector and private sector actors. They are independent, non-profit, member-based organisations, which combine funding from the government and the private sector. Besides, the intermediary organisations act as brokers and networkers, and play the important task of translating and co-ordinating the emerging fields of knowledge, among the government, academia (scientists) and other stakeholders. They have strategic roles in developing capacity and enhancing the impact of the polar science programme to the local community. Generally, intermediary organisations are responsible for advising, developing strategies, and coordinating research and development (R&D), infrastructures, expeditions, and EOC in the national polar programme. In the context of EOC, intermediary organisations create linkages between universities and other institutions for polar research, maximize synergistic potentials and innovation in particular sectors related to polar research, raise polar research funding in collaboration with public and private sectors, and act as regional development and promotion agencies. Intermediary organisations for Malaysia may refer to National Antarctic Research Centre and Sultan Mizan Antarctic Research Foundation that play the role in delegating the national initiatives in YOPP-EOC. Both agencies were established to support and coordinate the national polar programme in Malaysia. Both organizations have different roles, but equally serve as a "One-Stop Centre" for the Malaysian involvement in the polar regions, especially in providing advice, co-ordinating research, and expedition, particularly in EOC.

Extremely important in the process of changing social perception towards polar regions is the role of universities. Mikulik and Babina (2009) stated that universities educate future politicians, scholars, engineers, and planners – people who will set the direction of human development. Thus, they have to lead in promoting environmental equilibrium because they have a right and duty to indicate where problems exist. According to Ali (2013), universities serve the people; they advise governments in policymaking decisions; they help to develop skills, create knowledge, and train leaders. They are at the centre of crucial research, through which a country can stimulate innovations as well as attract foreign investments and engage in scholarly and scientific commerce. When universities are given the opportunity to thrive, they can also help to promote an open, modern, civil, tolerant and democratic community, for it is only through higher education that deeper ethical and moral values can be inculcated. The scientists or academia from public and private university involved in polar region research and studies are playing a more prominent role to ensure the success of YOPP-EOC. Since teaching, research and community engagement are the core business of the university, it is only most appropriate for university to play a greater role in strengthening and promoting YOPP-EOC at the school and university level.

Scientists and their institutions need to consider how they can build scientific communication programmes that provide solid technical information and opportunities for input. In addition, they need to have dialogues with their local public regarding the role of the polar regions and their sustainability issues. Leshner (2005) stated that science and scientists play a vital role in society and the degree of influence wielded by scientific opinion, the reputation of scientific bodies for impartially rendered insight, the priority accorded to scientific research and education all have contributed to the success of nations. Therefore, the scientists need to address the significance of the fundamentals and applications of their studies on polar regions for their publics. Ricci and Egerton (2010) highlighted that the polar regions become a crucial part of mankind's heritage and hold a special place in the heart of many citizens, while the exploration and discoveries in these regions have stimulated the imagination of the public. Thus, scientists must be able to capture the interest of the public and the young generation, to convey the beauty of the polar regions and the fascination of polar research. They also have to ensure that scientific culture and the humanism inherent in polar science and expedition must be transmitted more effectively to society, especially to the young citizens. To ensure the effective dissemination of science knowledge about the polar regions, scientists play a critical role in transmitting it in layman's term to the public in a number of ways. First, they can do it by publicizing their research and expeditions in newspapers and magazines, by giving public lectures at schools and universities, and in forums or interviews. Additionally, they can publish their research in electronic media, by writing books or commenting on complex issues of public concern related to polar regions such as climate change, rise of sea level, and global warming. Thus, scientists need to improve their communication skills, with the school communities, the general public, the media and the policy makers (Xavier, 2013). Meanwhile, Ricci and Egerton (2010) highlighted that communicating knowledge and findings about the polar regions to the general public in a way that holds their attention is valuable and will help stimulate interest in scientific training and research. Therefore, it is necessary that the polar scientist, in the scientific or social field should seek to

speak with one voice about the polar regions. Effective communication dedicated to polar issues by scientists is a vital component that is crucially needed to support and guide policy makers to help reach decisions in issues pertaining to education, finance and governance.

In particular, teachers (educators), early career polar researchers, schools and university students are identified as a part of the grassroots for a successful YOPP-EOC; they are its building blocks and foundations; they can depict its attitudes and drive its progress. This is why creating the best environment and encouraging good strategies in EOC are an integral part of a national agenda on polar regions. The youth or young citizens, particularly school and university students have been identified as part of a key group that becomes the feeder for this programme; they serve as the foundation for the development of the national interest on the polar regions in future. Grimmette (2014) noted that the effects of environmental education programmes on youths should be creating environmental awareness, building a connection to the environment, and changing the perceptions of youths on the environment. In addition, Kirk (2010) highlighted that today's youths are the policy and decision makers of the future. Thus, to understand the future resolution of environmental concerns, the effects of adolescents' environmental attitudes, knowledge and self-efficacy on environmental behaviours must be studied. In the context of Malaysia, the chief executive of YPASM once said that young Malaysians need to be encouraged into this line of research. It is important not just in terms of capacity building, but that new blood will give rise to new ideas (The Star, 2015). Surely, engaging these key groups at an early stage can help shape future development of the national polar regions agenda to be more meaningful and useful to these groups. Thus, at the national level, the relevant institutions need to develop a framework of pedagogy which incorporates holistic insights to promote the roles of polar regions to ensure global sustainability through the national education curriculum, outreach and communication among Malaysian young citizens. According to Shabudin et al. (2015), national polar governance and researchers have to contribute more energies and enthusiasm towards promoting the roles of the polar regions in terms of global sustainability, research activities, and scientific innovation to the local public, especially to the young citizens. Berman et al. (2014) highlighted that the development of the network between educators and scientists has the potential of breaking down some of the present walls that restrict international collaboration and understanding, provide educators with topical and reliable information and share best practice internationally in an efficient and effective way. The governance and management of schools and universities need to support and encourage participation of their communities in EOC activities and develop a strategy to produce apprentices with new talents in the field of science, policy, geopolitics, and international relations regarding the polar regions.

Media and funders are identified as the key support groups to boost the national agenda in YOPP-EOC and strengthen the national interest on the polar regions. The electronic, print and social media have a critical role to play in facilitating public understanding of the roles of polar regions and highlighting the national involvement especially in research and expedition. Stamm, Clark, and Eblacas (2002) highlighted the importance of public understanding of the environment and have identified it as a mass communication problem. The key message of the importance of the polar regions' environmental issue has not been properly conveyed to the audience. Lugalambi et al. (2011) mentioned that it has

long been acknowledged that the media play an important role in society by providing critical information to the way people comprehend and make sense of the world in which they live. According to McCombs (2002), the pictures in people's minds about the outside world are significantly influenced by the mass media, in terms of what the pictures are and what they are about. Media also has the ability to influence public opinion and public consciousness, making it a powerful tool that can persuade the public into taking actions (Azmi et al., 2015). Therefore, the media should have explicit guidelines in their coverage of polar regions issues and Malaysia's involvement to ensure a proactive approach is used in looking for and publishing stories relating to these issues.

Meanwhile, in this context, funders are referring to industry and corporate sectors through their corporate social responsibility (CSR) initiatives. Bhattacharya et al. (2009) stated that the notion that a company's investment in CSR initiatives can provide returns to the company is commonly referred to as the business case for CSR. This is supported in the scholarly literature by increasing evidence showing that individuals from various stakeholder realms (e.g., consumer, employment, investment) reward those companies engaged in CSR activities. CSR initiatives on polar regions can be implemented by supporting research activities, expeditions and outreach programmes. Thus, national polar governance has to highlight the key issues such as wilderness, climate change, and sustainability to attract the participation and investment of funders in YOPP-EOC.

The establishment of this strategy provides guidelines for polar education and outreach, and enhance the communications activities at all levels and consequently, it will sustain and strengthen the national interest on polar regions. An effective approach for stakeholder synergy in the context of EOC is needed as a part of the national policy strategy on polar regions. This would ensure that public appreciation and understanding about the roles of the polar regions for peace, science and sustainable future are enhanced. The collaboration of multi-stakeholders from various institutions serves as a key to strengthen this bottom-up strategy. This plan is important to serve as the basis for EOC decisions and works throughout YOPP at the national level. Consequently, it will ensure that the national interest in the polar regions can be sustained, and the foundation needed to establish a scientifically and technologically savvy, dynamic, and innovative society for the future development of the polar regions can be strengthened.

Conclusion

Scientific knowledge regarding the polar regions has the potential to spark an array of learning that can foster awareness and understanding of mankind on issues such as climate change, global warming and sea-level rise and can potentially drive local action into issues such as sustainability, globalisation, socio-scientific issues, global commons and science diplomacy. The major goal of scientists and science education on the polar regions is to ensure that every individual has some basic level of scientific literacy about these regions. Education, outreach and communication (EOC) initiatives serve as a medium to develop awareness and understanding on the role of the polar regions in terms of global sustainability and to deliver information and publicity about the national agenda. Consequently, this will sustain and strengthen the national appreciation and interest of various stakeholders on the polar regions. To ensure the success of

polar YOPP-EOC efforts, it is crucial that existing resources need to be coordinated, communities linked, partnerships developed, access to data and content from the polar regions made available, funding to develop new programmes secured, and post-IPY programmes organised. Information from this paper will advance scholarly understanding about the nature of knowledge about the polar regions. In addition, it shows the importance countries involved with polar regions to develop strategies by applying the EOC in their national polar policy, especially for co-ordinating involvement of multi-stakeholders and generating funding. Consequently, this would contribute in the designing of the national strategy and EOC initiatives, especially during the Year of Polar Prediction (YOPP) (mid-2017 to mid-2019). Besides, the information will serve as elements for consideration for the policy makers when establishing a new National Polar Policy for Malaysia as well as in designing strategies for governance in the polar regions.

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