IFIP AICT 655

Robert Nowak
Jerzy Chrząszcz
Stelian Brad (Eds.)

Systematic Innovation Partnerships with Artificial Intelligence and Information Technology

22nd International TRIZ Future Conference, TFC 2022
Warsaw, Poland, September 27–29, 2022
Proceedings

Springer

About this book

This book constitutes the refereed proceedings of the 22nd International TRIZ Future Conference on Automated Invention for Smart Industries, TFC 2022, which took place in Warsaw, Poland, in September 2022; the event was sponsored by IFIP WG 5.4.The 39 full papers presented were carefully reviewed and selected from 43 submissions. They are organized in the following thematic sections: New perspectives of TRIZ; AI in systematic innovation; systematic innovations supporting IT and AI; TRIZ applications; TRIZ education and ecosystem.

Systematic Innovation Partnerships with Artificial Intelligence and Information Technology

22nd International TRIZ Future Conference, TFC 2022, Warsaw, Poland, September 27–29, 2022, Proceedings

Editors:

- Robert Nowak,
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Part of the book series: IFIP Advances in Information and Communication Technology (IFIPAICT, volume 655)

Conference series link(s): TFC: International TRIZ Future Conference

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Acknowledgements

The authors are greatly thankful for the project funding from Ministry of Higher Education (*Kementerian Pengajian Tinggi*) and *Formulation of TRIZ-based Sustainability-Oriented Innovation Model for Indigenous Knowledge Management* (I03/FRGS/2009/2020). The authors would also like to thank the community leaders, local champions, and villagers for sharing their indigenous knowledge.

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Bibliographic Information

- **Book Title** Systematic Innovation Partnerships with Artificial Intelligence and Information Technology
- **Book Subtitle** 22nd International TRIZ Future Conference, TFC 2022, Warsaw, Poland, September 27–29, 2022, Proceedings
- **Editors**Robert Nowak, Jerzy Chrząszcz, Stelian Brad
- **Series Title** IFIP Advances in Information and Communication Technology
- **DOI**https://doi.org/10.1007/978-3-031-17288-5
- **Publisher**Springer Cham
- **eBook Packages** Computer Science, Computer Science (R0)

- **Copyright Information** IFIP International Federation for Information Processing 2022

- **Hardcover ISBN** 978-3-031-17287-8Published: 24 September 2022
- **Softcover ISBN** 978-3-031-17290-8Due: 08 October 2023
- **eBook ISBN** 978-3-031-17288-5Published: 23 September 2022
- **Series ISSN** 1868-4238
- **Series E-ISSN** 1868-422X
- **Edition Number** 1
- **Number of Pages** XII, 480
- **Number of Illustrations** 70 b/w illustrations, 95 illustrations in colour
- **Topics** Artificial Intelligence, Computing Milieux, Coding and Information Theory, Database Management, Mathematics of Computing, Information Storage and Retrieval

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TRIZ-based Approach in Capturing and Managing Indigenous Innovation and Knowledge

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Abstract. Indigenous people who are still connected to traditional lifestyles and are living closely in touch with nature's patents, remain custodians to vast treasures of knowledge. The ability to tap on indigenous inventions can be useful within a contemporary context in providing insights to help solve emergent problems such as global warming and climate change. This research focuses on exploring ways to capture this implicit and tacitly held knowledge among these remote indigenous communities of Sarawak, Borneo. Engaging with the local community in exploring the immense challenge requires a participatory model for eliciting innovative expressions across time and space boundaries. Mechanisms to associate such discovered knowledge within the context of current scenarios requires a standard framework for achieving the alignment. In this paper, a TRIZ-based framework for connecting to and mapping these past innovations has been proposed. The 40 inventive principles of Genrich Altshuler has been adopted as a means of bridging knowledge gaps and connecting the diverse knowledge forms. The collection of customized TRIZ instruments served as a collaborative visual knowledge mapping framework for acquiring and organizing knowledge for local indigenous communities. This study has demonstrated the ability to unlock tacit knowledge amongst community knowledge-custodians living in remote and isolated communities. The 40 Inventive Principles served not only as an index for innovative expressions but also as a good platform for these communities to make systems innovation as a way of life, and also to acquire expertise from external sources. The continuing efforts in knowledge-based activities has a potential for expansion to be used by other communities. Despite the initial challenges where there was a need to address language and intergenerational gaps, the proposed model has also demonstrated interest amongst youths to connect to their roots and share the past inventive moments with community elders.

Keywords: TRIZ, indigenous inventions, knowledge-based innovation, knowledge acquisition and knowledge representation.

1 Introduction

1.1 Knowledge and Innovation

Societies where people have learned to live together in a civilized manner demonstrates the long pathways undertaken to achieve this state. Knowledge is the thread in that can be passed down to succesively to bring cumulative benefits [17].

However, there are well known types of knowledge such as the explicit and tacit knowledge [3]. Explicit knowledge is something that can be easily passed down to another person i.e.how to do a certain task. Meanwhile, tacit knowledge is something that is learned in an intangible way which is usually harder to express as it is a sort of knowledge by 'feel'.

The sharing of knowledge brings about innovations [7] that can help a community to improve their methods of doing things, improving their sustainability [6]. Genrich Altshuler, the father of TRIZ, has highlighted innovation is repeated, when a systematic approach of transfer is in place.

In relation, this paper aims to exploit TRIZ based approach for capturing and managing traditional knowledge can be adopted by the indigenous communities in Sarawak. The TRIZ instruments co-created with the community serves as a collaborative visual knowledge mapping framework for acquiring and organizing knowledge for local indigenous communities.

1.2 The Indigenous People of Sarawak

According to Mamo [9], the International Work Group for Indigenous People assessed 13.8 percent (4,369,177) of all Malaysians as indigenous in 2017. In the Peninsular of Malaysia, 18 Orang Asli tribes, namely Semang, Senoi, and Aboriginal-Malay, are referred to as indigenous people, accounting for 0.7 percent (182,000) of the total 26,000,000 Peninsular Malaysians. Meanwhile, the indigenous people of Sarawak are known as Dayak or Orang Ulu, and they are made up of ethnicities such as Berawan, Bidayuh, Bisaya, Iban, Kejaman, Kenyah, Kayan, Kedayan, Kelabit, Lun Bawang, Melanau, Penan, Punan, Sekapan, and Ukit. They account for 70.5 percent (1,932,600) of Sarawak's total population of 2,707,600. We therefore see an importance of indigenous knowledge being passed down across generations.These communities have rich history in terms of their story, innovation spirit in their capacity to overcome hardships and difficulties in their quest for resilience.

1.3 Problem Statement

In this study, we explore the tacit knowledge capture and management for use in a particular community as a case study. After several discussions with community members in building on our past engagements [Franklin, 2022] with the nomadic Penen community of Long Lamai, we have come up with a cause-and-effect chain analysis which illustrates that indigenous innovations requires a dedicated framework together with an ecosystem for it to be captured and managed properly.

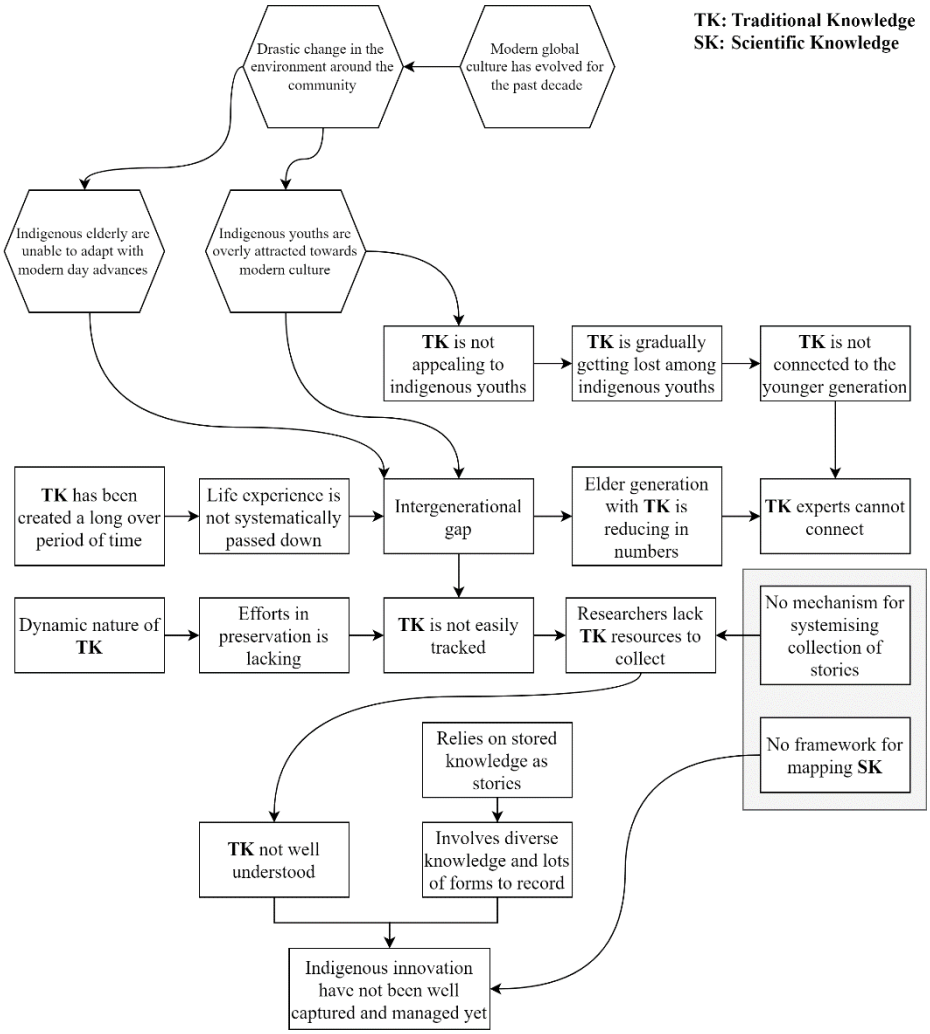

Figure 1. Cause-and-effect Chain Analysis

Major part of the problem has to do with:

(i) no available mechanisms in use for the capture the indigenous knowledge.
(ii) TRIZ (other forms of SK) tends to be too complex to be well understood by rural indigenous communities.
(iii) integration of TRIZ concepts with indigenous creative expressions is not well-founded

It seems that the traditional knowledge has faced several implications due to the lack of capturing methods and it is difficult to map the traditional knowledge with scientific knowledge. That is partly because traditional knowledge is cumulated over time making it harder to trace.

2 Case Study and Related Works

2.1 Innovation in Indigenous Community

The Penans are an indigenous group that may be found across central Borneo Island. Their communities are mostly concentrated near the Baram River in Sarawak, Malaysia. Historically, the Penans were divided into two groups known as the Western Penan and the Eastern Penan [11]. The livelihoods of these two Penan groups are virtually the same. According to Survival International [15], the Penan people live a stable existence in contrast to their nomadic lifestyle before to the colonial era in Sarawak.

According to several sources [12], [10] and [8], the Penans' major source of income is still hunting wild animals, scavenging for wild foods or plants, and recently expanding into agriculture and fishing. They are also observed to perform arts and handicrafts like as basketry and musical instruments in terms of creativity [13], [2].

Even though they have formed settlements, a few of the Penans continue to live as nomads. In essence, there are marginalized people who are really alienated from the modern world devoting their majority of their time in nature. However, just because they have been living with nature for so long does not imply that they should be subjected to being left behind in terms of innovation capacity for advancement.

2.2 Co-creation and Participatory Practices

Both of co-creation and participatory practices are the methods used to get communities to involve themselves in a development. Based on a work done by Grant [5], the identification of hierarchy within the co-creation and participatory model is well defined.

The purpose of the hierarchy shows that the importance of each approach has its own specific purpose but still aiming to make community organisers to work together with the stakeholders. Refer to Table 1 for a complete view of both methods with the highlighted ones as the as our main practices for this study.

Table 1. Different approach between Co-creation Practices and Participatory Practices

Co-creation	Building connections	Connectivity	Actions by community member and organizers
		Collaboration ethos	
	Collaborative project design	Community consultations	
		Oral history interviews	
		Storytelling and knowledge sharing	
Participatory Practices	Participatory methods for developing collections	Informal description practices	
		Informal archival or preservation practices	
		Post-custodial practices	
		Social media as an online forum	
	Collecting multiple narratives or perspectives	Content organization	
		Narratives in description	

2.3 Preliminary works in Integration of Indigenous Sign Language (Oroo') with TRIZ

The works as described in this research was started by our research team with an ethnographic study by the co-author, Franklin George. As a Penan who learnt the traditional language form as a youth, initiated the mapping of the Penan forest twigs-and-leaves language symbols into the appropriate local meanings. The approach evolved through co-creation and participatory practices the joint understanding of indigenous knowledge and TRIZ concepts from the Penan indigenous perspective. The training on TRIZ principles was facilitated by team members undergoing Level 1 and Level 2 MAyasian TRIZ syllabus. The use of oral interviews and focus group discussions with community experts and the research team led by the second author who is a International TRIZ L3 certified, ensured the correctness in mapping with TRIZ inventive principles. [4]. The oral interviews involve local champions that consisted of Penan elderly and formulated a way of integrating TRIZ inventive 40 principles and Oroo' (a visual communication methods as used by the Penan). Over 50 Penan Oroo' sysmbols were mapped to the 40 TRIZ Inventive principles. The list below represents the steps of mapping process of his Oroo' to 40 Principles.

1. A collection of Indigenous Principles with their own name and meaning/message.
2. A collection of localized 40 inventive principles
3. Categorization of 40 inventive principles based on its physical state, function and meaning.
4. Mapping of the Inventive principles and 40 inventive principles
5. A collection of indigenised inventions as a community knowledge bank

2.4 Indigenous Innovation with Function-Behaviour-Structure (FBS)

Based on the work of Altshuller [1], the compilation of 40 Inventive Principles is an instrument based on an intensive study of existing patents serving as an index for mapping traditional inventive knowledge to help solve emergent complex problems such as climate change and global warming.

However, with just the 40 Inventive Principles, we can use the characteristics of each of it in with the proposed framework. In relation with the principles, there are other ways for us to go in-depth with the principle by applying the *Function-Behaviour-Structure (FBS)* with each principle [14]. See Table 2 for a simplified connotation.

Table 2. Simple FBS connotation based on Russo & Spreafico [14].

	FBS Connotation	Proposed FBS Connotation
Function	Purpose and intention of the design [14]	What response do we expect from an indigenous innovation expression?
Behaviour	Expected or obtainable characteristic from structure [14]	What kind of activity that needs to be done to fulfill the function?
Structure	The relationship of the elements in the design [14]	Definition of ideas to some intermediate structure to scientific knowledge.

3 Findings and Discussions

3.1 TRIZ Based Approach to Capture Tacit Knowledge

In the first run, we collect relevant stories from their indigenous experience and perspective on solving a problem the traditional way and about their traditional artifacts.

Similarly, these stories will undergo a co-organisation with the community to get an in-depth opinion through oral exchange.

Then, we will conduct a consultation for the TRIZ experts to brainstorm the optimal way to link the traditional knowledge to structural knowledge from TRIZ.

After consulting with the experts, we referred to the community to validate the proposed framework or model. Making the model also required us to translate it into a local language to be understood with the indigenous community.

The proposed mechanism shows a full view of the process in a bigger picture. The application of TRIZ inventive principle will also be discussed later.

3.2 40 Inventive Principles in Capturing Indigenous Knowledge

In this paper, 40 Inventive Principles will be the basis of knowledge capture. This will be an index to classify various indigenous processes and products. This index will also assist the experts and the indigenous community to map the indigenous products.

Based on *Function-Behaviour-Structure* (FBS) ontology by Russo & Spreafico [14], there is an emphasis of function and behaviour in the structure. As FBS requires a thorough understanding of the concepts, a model has developed to support the TRIZ experts and indigenous community experts to map their indigenous inventive moments. Table 4 shows the elements in the capturing mechanism meanwhile, Table 3 and 4 shows how the way the indigenous innovation is mapped with TRIZ 40 Inventive Principles.

Table 3. *Telikit* in FBS and TRIZ Form

Indigenous Innovation	*Telikit*
Structure	
Application How can we hone an apprentice's hunting-skills without risking their life or their safety?	**Method** We use a training in simulated gamified environment to hone the skills until they are ready for the real hunt.
Innovation Description *Telikit* is a game used to train Penan youngsters to hunt using bamboo hoops and a long stick. Bamboo hoops represents the prey, and the long stick represents the spear used to stab the prey. When the hoops are thrown to a player holding the stick, the player must catch the fast-moving hoops by swinging the stick into the center of the hoop, simulating stabbing the prey into their vital organs. The game is used to evaluate the readiness of the Penan youngster to be a hunter. The difficulty of the game also can be increased by throwing a smaller bamboo hoop with increased speed and intensity.	
Function	Inform Penan youngsters on basic hunting skills and knowledge

Behaviour	Training using a game to simulate hunting in a safe environment
Function predicates	inform(youths), empower(apprentice), imbibe(core values)
Inventive Principles as Structural Elements	
10. Preliminary Action	Early preparation for optimal result
26. Copying	Use simple and easily available model-copies

Table 4. Water logistics in FBS and TRIZ Form

Indigenous Innovation	Logistics using water vehicle
Structure	
Application How to move large objects using small water vehicles?	**Method** Change the physical capability of water vehicle to float large objects or alter the objects to fit in water vehicle.
Innovation Description Transporting objects in the waterways are a challenge for the Penan community in Long Lamai because the only way to get there is through the river. Based on the situation, the object can be too large to carry in a single boat, thus a way of transporting it by the boat must be tackled.	
Function	Moving large object through the waters
Behaviour	• Use a bigger carrier • Disassemble the object • Compact the object • Combine smaller boats to increase surface area
Function predicates	move(large-object), supports(movement), merge(boats), configure(boat-structure)
Inventive Principles as Structural Elements	
1. Segmentation	Divide object into smaller parts
3. Local Quality	Make objects to operate in its ideal condition
5. Merging	Merge objects or operations

As seen above, the proposed framework based on FBS can aid in the collecting and mapping process significantly. This process should be co-created with the community and mentored by TRIZ experts for interpreting and extracting the innovations from the stories and interviews done with the Penan community.

3.3 Managing Captured Indigenous Innovations

In managing the indigenous innovations, it is more suitable to store the indigenous innovations using technology which can handle a large volume of information. The template for knowledge capture has been discussed in the previous chapter. However, some terms have to be simplified.

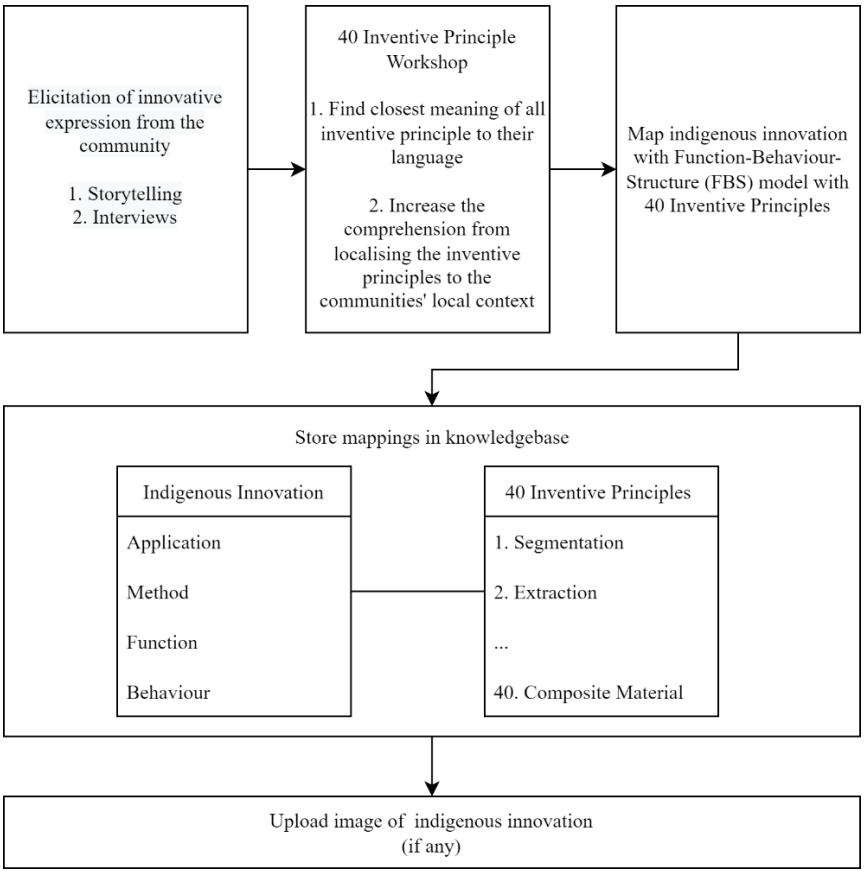

Figure 3. Methods of managing indigenous innovations using Google services.

3.4 Future Works

The potential of this preliminary work is for the mechanism to have a sustainable model where every community can benefit from this. The next version of this model will introduce us with a standalone software which can be utilized by using any mobile device with ability to store the multimedia contents of the products in a cloud-based storage. The knowledge-base of past inventions will be conserved, and the communities can take advantage of a potential software to be developed by using the stored knowledge to foster innovation as a culture. Future works will explore the modelling of Altshuler's matrix as a knowledge-base of inventive patterns.

3.5 Benefits of Implementing Co-creation and Participatory Practices

The importance to know how to work the community has been rising because there are a lot of protocols that needs to be followed. By providing the community a clear course of action that needs to be done in the project will help the organisers and experts to work flawlessly.

In the Sarawakian indigenous communities, the researchers must follow the community protocols. Since the communities are the ones to manage their own resources, we will have to learn the community protocols to avoid against legal actions [16].

Co-creation and participatory practices also must be shown to the community before proceeding to do any further steps. If implemented properly, the community will be more than welcome for us to do research in their native land.

Acknowledgements The authors are greatly thankful for the project funding from Ministry of Higher Education (*Kementerian Pengajian Tinggi*) and *Formulation of TRIZ-based Sustainability-Oriented Innovation Model for Indigenous Knowledge Management* (I03/FRGS/2009/2020). The authors would also like to thank the community leaders, local champions, and villagers for sharing their indigenous knowledge.

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