



Review Article

Application of systems theory to explore knowledge gaps of standardization: A case of the standard organization of LAO PDR

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Abstract

Systems theory assists policymakers and practitioners in public and private organizations in its management development, including planning, efficient operations, and holistically understanding organizational situations. This article aimed to present the application of systems theory in locating the knowledge gap in the standardization process within the Department of Standardization and Metrology, Lao PDR. The narrative literature review approach was applied to synthesize this article. Systems theory application seeks to understand the relationship among input, output, feedback, and the process of standard designation to procreate the three ideas and narrow down on actual and specific knowledge gaps. This article exhibits the fundamental key concepts of systems theory and standardization for scholars and practitioners to learn and utilize in their further study and development of standardized works.

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Introduction

The International Organization for Standardization (ISO) defines the International Standard as the “document containing practical information and best practice. It often describes an agreed way of doing something or a solution to a global problem” (International Organization for Standardization [ISO], 2020a). Goods, products, and services, including manufacturing systems that meet standards, will be imprinted with the official labels such as ISO 8187 (household refrigerating appliance),

ISO 16949 (automotive), and ISO 45001 (health & safety). These badges assure consumers that their products are safe, reliable, and of good quality (International Organization for Standardization [ISO], 2019). Equipment bearing these seals guarantees compatibility with other devices and, thus, improves user confidence (European Committee for Standardization, 2021). For business organizations, standards are powerful tools to enhance operations and manage processes effectively and sustainably, including preventing risks (The British Standards Institute, 2019). Hence, standards are beneficial to both manufacturers and consumers.

Standard works will have an organization performing a direct role and function. ISO is a well-known standards organization responsible for assigning international

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standards. Regional standard organizations such as the European Committee for Standardization (CEN) and the Pacific Area Standards Congress (PASC) also design standards for utilization in their respective regions. There are also the national standard organizations, such as the American National Standards Institute (ANSI), Japanese Industrial Standards Committee (JISC), Thai Industrial Standards Institute (TISI), and Department of Standards and Metrology of Laos (DOSM). In general, there are three main functions for every standard organization: (1) standard designation; (2) standard inspection; and (3) standard accreditation. Each function has a unique process, method, timing, and consumption of resources. Establishing standard work involves stakeholders from diverse sectors such as manufacturers, consumers, and expert groups of organizations (International Organization for Standardization [ISO], 2021). The complex task of instituting standard work requires systematic preparation, planning, and implementation, requiring organizations to perform the roles and functions immediately.

Organizations across diverse sectors have applied systems theory in management development. Since an organization is also a system of dynamic change, it transforms inputs or resources to produce the intended outcomes and utilizes their effects or feedback to adjust future inputs to the system (Millett, 1998). Systems theory guides businesses to understand complex management and enterprise marketing issues, such as knowledge, quality, relationships, complexity, and adaptability (Mele et al., 2010). It expands appropriate alternative ways of solving and developing an organization (Kast & Rosenzweig, 2017). Yawson (2013) revealed that systems theory also contributes to uncovering relevant research questions in human resource development issues. Systems theory is therefore essential for multidimensional organizational development, both operational and management mechanisms.

As described above, systems theory is applied to develop organizational management in various contexts, but there are limitations in standards organizations, especially in creating new standards. In this article, the author presents the application of systems theory in the context of a standards organization believing that its utilization would confront knowledge gaps in its standardization process. The author chose the national

standardization department of Laos to illustrate this belief. The four main topics covered in this presentation were: (1) fundamental key concepts of systems theory; (2) ISO's standard designation procedure; (3) relationship of the systems theory and the ISO standardization; and (4) application of systems theory to uncover knowledge gaps of the national standardization of Laos.

Methodology

In this review article, the author applied the narrative literature review approach to summarize and synthesize the results composed of four steps: (1) conduct a search; (2) identify keywords; (3) review abstract and articles; and (4) document result (Demiris et al., 2019).

Conduct a Search

Conducting a search step is important for exploring numerous databases related to the topic of this article. The Google Scholar search engine was employed for accessing the database from many webs' database. After entering <https://scholar.google.com/>, keywords: e.g. "general system theory: pdf" "ISO" standardization stage" "ISO" were typed into the search box on Google website. The result of searching showed files of matching content and link addresses for retrieving or downloading papers.

Identify Keywords

This step helped get the more relevant articles by using several keywords from the previous article that had been indexed on the abstracts page, selecting and typing related keywords before finding a paper that was pertinent to our review question. In this step, more than fifty articles or papers from the database searching process were found.

Review Abstracts and Articles

In this step, scanning reading was utilized to explore all duplicated papers and exclude them. The papers were grouped by topic, GST concept, standardization concept, and research article. Then, the content in abstracts and articles was reviewed carefully with text highlight

and a short note. The layout of the article was drafted in this step.

Document Results

In the last step, to summarize and synthesize, vital contents were integrated into the writing as appropriate. To draw meaningful results, the author thought intensively attempting to link the GST concept with the standardization process. The comparative thinking technique was applied to expose knowledge gaps in the national standardization of Laos.

Results

Fundamental Key Concepts of Systems Theory

A brief history of system theory development

In the paper, *The History and Status of General System Theory*, Ludwig von Bertalanffy (1972) described the origin of the system concept according to what Aristotle said, “the whole is more than the sum of its parts.” This statement provides a fundamental perspective for scientists towards a holistic world view in understanding natural phenomena.

In the first half of the 19th century, scientific knowledge developed rapidly, especially in physical and biological sciences. This development was fundamental to the formation of systems theory. Lotka (1920) laid the basic principles of certain elements in nature. Defay (1929 cited in Chen & Stroup, 1993) described the interaction between physics and biology, and Schrodinger (1944) introduced the principles of thermodynamics. Weiner (1948) studied the control and communication of organisms through machines and called it “Cybernetics.” This progress influenced the development of science in multiple fields such as computer science, engineering, biology, philosophy, psychology, and other branches of social science (Chen & Stroup, 1993).

Several branches of sciences utilized and applied system theory in the second half of the 19th century. Boulding (1985) pointed out the General System Theory as the backbone of science because it assists in forming the structure or work system. In addition, it organized the knowledge of sciences more obviously through

systematized combinations. Forrester (1989) played a crucial role in explaining the system dynamics of the business cycle: cause, effect, and feedback. Later in 1968, von Bertalanffy published a book called “General System Theory: Foundations, Development, Application.” Recognized as the founder of General Systems Theory (GST), von Bertalanffy (1968) defined the word systems as “a set of elements standing in interaction.” In 1954, he founded the International Society for Systems Sciences (ISSS), which became a forum for scholars to exchange and develop systems theory knowledge (International Society for Systems Sciences 2021).

After 1970, social scientists began to apply the system theory. Parsons, a sociologist, conveyed the social systems theory by describing its four functions: (1) adaptation function; (2) goal attainment; (3) integration function; and (4) latency (Friedman & Allen, 2014). Luhmann (1995 cited in Stichweh, 2011) extended Parsons’s idea by focusing on a broader understanding of the system and pointing out the differences between systems and the environment. After the 1980s, system theory advanced swiftly, with academics applying it to pursue knowledge in various fields and developing the computer software called “STELLA” to analyze systems (Richmond & Peterson, 1984).

Contemporary scholars implore distinctive categorizations for the system theory. Pickle (2010) set this out in four major categories: (1) general system (s) theory; (2) cybernetics; (3) game theory; and (4) decision theory. Similarly, Cordon (2013) also grouped the system theories into: (1) general systems theory; (2) complex-adaptive systems; (3) chaos theory; and (4) integral theory. Adams (2012) divided systems theory into six main streams: (1) general systems theory; (2) living system theory; (3) mathematical system theory; (4) cybernetics; (5) social system theory; and (6) philosophical system theory. Adams et al. (2014) also synthesized and summarized the general rules of system theory into seven axioms: (1) centrality; (2) contextual; (3) design; (4) goal; (5) information; (6) operational; and (7) viability. These principles are linked to the six divisions of sciences for a total of 42 branches. Therefore, systems theory is a multidisciplinary theoretical foundation and an interdisciplinary framework.

Key concepts of system theory

In this part, the fundamental key concepts of system theory are explained as follows;

1. System: A system is a complex of interacting elements (von Bertalanffy, 1956). “Systems are nested in a hierarchy, that is, systems consist of subsystems and systems operating within the environment” (Schoech, 2004). Its main intention is to absorb inputs, process them, and produce outputs. Outputs are defined by goals, objectives, or common purposes (Sauter, 2017).

2. Components or subsystems: Every system has at least two interconnected elements (Kast & Rosenzweig, 2017). A single part of a system is called a component. Each component refers to any part of a system or subsystem. The element is a terminology used to imply a smaller component separately (Cornell & Jude, 2015).

3. Input: The composition of inputs from the external environment may include people, capital, managerial, and technical skills (Cornell & Jude, 2015).

4. Process or transformation: The organization is generally described as transforming systems when it changes or converts inputs into outputs as its goal. The changes resulting from these interactions are called processes (Cornell & Jude, 2015).

5. Output: This is the exported matter/energy into the environment by the system. The output includes the final products or the throughput and the waste products (Katz & Kahn, 1978). Outputs of different kinds vary with the organization; they usually include one of the following: products, services, profits, satisfaction, and integration of the goals of various claimants to the organization (Cornell & Jude, 2015).

6. Feedback: The exchange of information between the system and its environment is regulated by a process called feedback. This method evaluates and determines whether the system’s outputs are inconsonant with the perceived outcomes (goals) that the system established for itself (Friedman & Allen, 2014). Negative feedback is the informational input indicating that the system deviates from a prescribed course and should be readjusted into a new steady state (Kast & Rosenzweig, 2017).

7. Hierarchy: Refers to the relative hierarchy of elements or parts that depend on each other from the smallest to the largest (Miller, 1965). A linear graph shows the relationship between two elements, which is the conceptual basis for understanding the hierarchy of relationships (Harary & Batell, 1981). Emergent

properties denote the levels in the hierarchy (Checkland, 1993).

8. Open–Closed systems: A closed system is completely sealed off from its environment. Conversely, an open system has a boundary exposed to some extent, allowing energy or influence to pass into and out of its system (Tamas, 2000). An open system, unlike a closed system, exchanges matter with its environment; closed systems “are isolated from their environment”, “living organisms are essentially open systems.” (Friedman & Allen, 2014; von Bertalanffy, 1968).

ISO’s Standard Designation Procedure

As mentioned in the introduction, ISO is a well-known standard organization. Hence, the ISO standardization stages are emphasized: (1) proposal stage; (2) preparatory stage; (3) committee stage; (4) inquiry stage; (5) approval stage; and (6) publication stage (International Organization for Standardization [ISO], 2020b).

1. Proposal stage: As its initial stage, the Standards Committee accepts or rejects a New Work Item Proposal (NWIP). After nominating qualified project leaders, the committee again votes via the electronic balloting portal. Considered next are the copyright problems, designing standards, and assessments. In this step, seven resources are required: (1) ISO/IEC Directives Part 1 and Consolidated ISO Supplement; (2) Form 4 - NWIP; (3) electronic balloting portal; (4) patent policy; (5) conformity assessment for standards writers; (6) global relevance policy; and the (7) Vienna agreement.

2. Preparatory stage: The parent committee appoints a working group (WG) to implement the work draft (WD) by a group of experts and the project leader. Standard drafts will be examined by circulating them among the members of the WG for improvement until it is of a reasonable standard. The WG also considers copyright, patent issues, and feasibility assessments. The parent committee then receives the standard draft and either sends it to the next step - the committee stage, or skips to the inquiry stage. Resources needed in this stage are the: (1) ISO TC platform; (2) ISO/IEC Directives Part 1 and Consolidated ISO Supplement; (3) patent policy; (4) conformity assessment for standards writers; and (5) how to write standards.

3. Committee stage: The parent committee provides feedback about the standard draft created by the committee members. Necessary revisions of its technical content and consensus among members must be achieved through voting. This step requires the following: (1) electronic balloting portal; (2) Form – limit date extension request; and (3) ISO/IEC Directives Part 1 and Consolidated ISO Supplement.

4. Inquiry stage: The committee secretary sends the draft international standard (DIS) to the ISO head office and its members. The ISO members will have only 12 weeks to vote and comment. To proceed, two-thirds of all members must approve the DIS, with no more than 1 in 4 members voting to disagree. In addition, if there are no technical content changes in the approved DIS, it proceeds to the publication stage. However, the next step is the final draft international standard (FDIS) if the DIS requires technical content changes. Resource requirements for this stage are the: (1) submission interface; (2) electronic balloting portal; (3) comment collation tool; (4) Form - limit date extension; (5) ISO/IEC Directives Part 1 and Consolidated ISO Supplement; and (6) draft submission.

5. Approval stage: Approved DIS from step 4 without technical revisions skips this stage. However, DIS which required technical modifications, shall be finalized by the parent standards committee. The committee secretary forwards the revised DIS, now FDIS, to the ISO head office for its members to vote within eight weeks. FDIS proceeds only after receiving a two-thirds favorable vote, with no more than one-quarter of ISO members voting to disagree. Resources required in this step are the: (1) submission interface; (2) Form 13 - report of voting on ISO/DIS; (3) electronic balloting portal; (4) ISO/IEC Directives Part 1 and Consolidated ISO Supplement; and (5) draft submission.

6. Publication stage: At this stage, the head office secretary publishes the international standards to its stakeholders and those who request the design standards. However, publishing the approved standard may take two weeks after its approval. The FDIS will have to go through editorial correctness, appropriate wordings, and spelling checks before the project leader and the committee secretary sign the document for publishing. The two resources needed in this stage are the: (1) ISO/IEC Directives Part 1 and Consolidated ISO Supplement; and (2) draft submissions.

The six stages of ISO standardization above indicate that every step requires resources for implementation. It includes a total of 28 resources grouped into 12 categories: (1) Directive & Consolidated Supplement (DCS); (2) Forms (F); (3) Electronic Balloting Portal (EBP); (4) Patient Policy (PP); (5) Conformity Assessment (CA); (6) Global Relevance Policy (GRP); (7) Vienna Agreement (VA); (8) how to write standard (GL); (9) ISO TC Platform (TCP); (10) Submission Interface (SI); (11) Comment Collation Tool (CCT); and (12) Draft Submission (DS). The time frame for the whole standardization process should not exceed 36 months or three years, depending on the voting result and the revision processes in each stage. However, the question remains. “How does the standardization relate to the system theory?”

Relationship of the System Theory and the ISO Standardization

As posed with the question above, this section explains the relationship between the ISO’s standardization steps and the system theory.

Sub-components occurring in the standardization stage

Figure 1 reveals that in crossing between the six steps of standardization and the system theory (input, process, and output), sub-components have occurred: resources, activities, and products. Also, the number of sub-components is different. The proposal stage requires seven resources in its five activities that determine rejection or acceptance of the new proposal. On the contrary, the two activities for the publication stage need two resources (DCS, and draft submission); to sign and publicize the new standard. The DCS is a vital resource required in every standardization step. Also utilized in voting four times is the online voting tool called EBP. The voting activity requires a resource (F form), which becomes an output and evidence that manifests the productivity of transformation. All products in every standardization stage show the rising of output sub-components.

EBP application contributes a more comfortable and faster voting

Analyzing the relationship between system theory and standardization indicates a critical activity: voting,

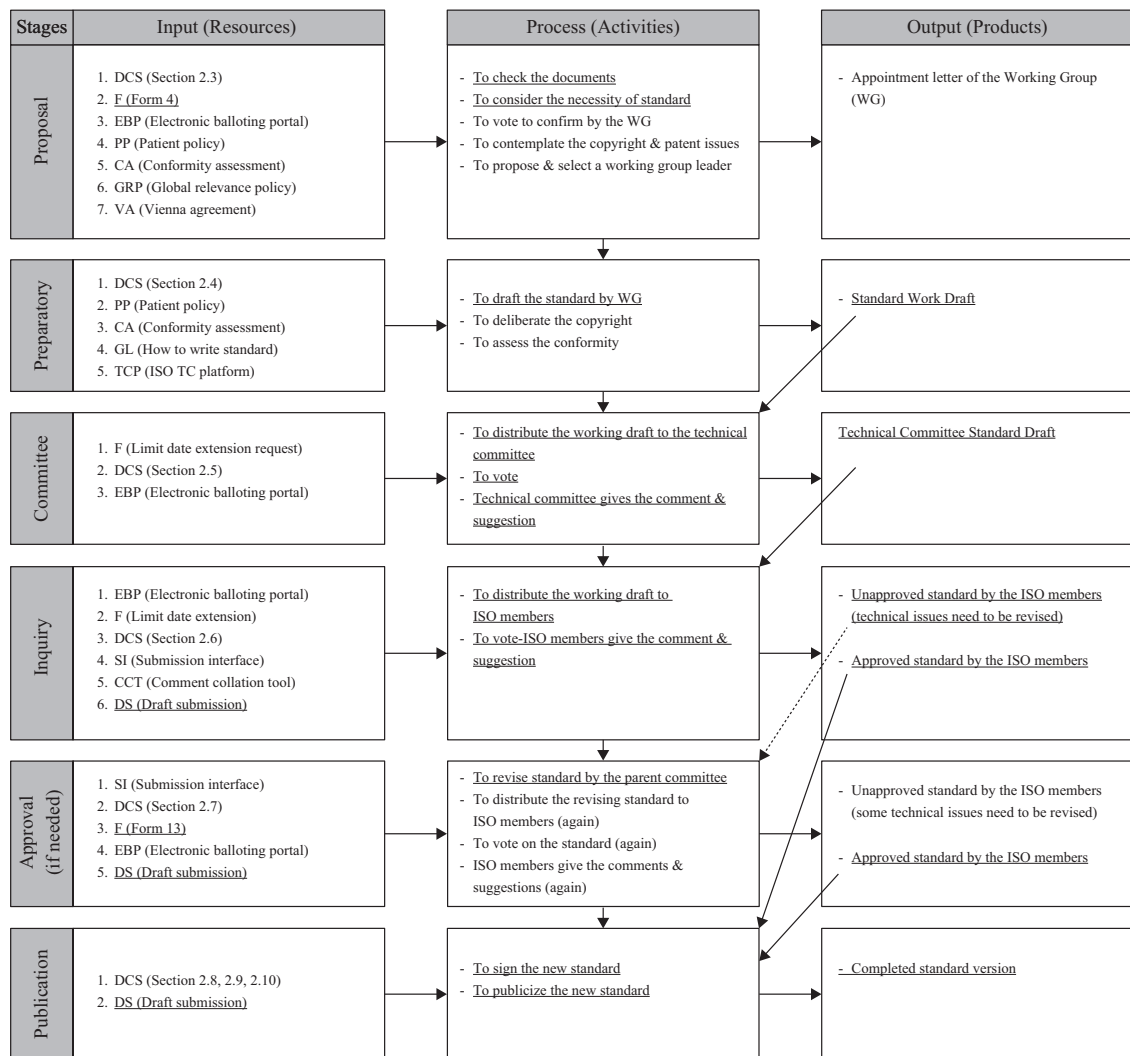
a resource-intensive exercise is an important activity that signifies, early or late, the completion of the standard. Figure 1 shows the frequency, four times of votes during the standardization stages.

EBP is one of the eight sub-programs of ISO Electronic applications for its stakeholders. This online voting portal contributes to a more comfortable and faster voting process among ISO members. They can do voting anytime, anywhere, and whenever accessible. EBP also supports the working draft and the committee group to communicate and share the information, saving time,

budget, convenience, and speed. Thus, utilizing online technology in the standardization process increases the efficiency of the organizational work, especially the voting activity that needs all stakeholders' participation.

Previous structure and mechanisms contribute to the implementation of standardization

The ISO organization structure consists of two parts: the ISO council and the parent committee. Firstly, the ISO council links the top and bottom with the standards council managing meetings and working closely with the



Acronym: DCS (Directive & consolidated supplement), F (Forms), EBP (Electronic balloting portal), PP (Patient policy), CA (Conformity assessment), GRP (Global relevance policy), VA (Vienna agreement), GL (How to write standard), TCP (ISO TC platform), SI (Submission interface), CCT (Comment collation tool), DS (Draft submission)

Figure 1 Relationship between the system theory and the standardization

Note: DCS (Directive & consolidated supplement), F (Forms), EBP (Electronic balloting portal), PP (Patient policy), CA (Conformity assessment), GRP (Global relevance policy), VA (Vienna agreement), GL (How to write standard), TCP (ISO TC platform), SI (Submission interface), CCT (Comment collation tool), DS (Draft submission).

technical management board (TMB). The TMB is responsible for establishing a working group for drafting the standards, voting, and revising. In addition, the central secretariat liaises with the standards council and monitors the implementation progress. The second part of the structure, the parent committee, manages all standardization activities. Members of this committee are the ISO president's committee, the council standing committees, the advisory groups, and the policy development committees (ISO, 2020). The six standardization stages demonstrate the relationship and transformation of the resources into products. As manifested in the preparatory stage, when a working group undertakes a resource transformation of the product, the working draft becomes a resource input for the next stage. These mechanisms explain the relationship of input, process, and output of the system theory.

After comprehending the relationship between system theory and the ISO standardization process, three constructs to acquire and fill the knowledge gaps in the standardization process in Laos were identified. These ideas are presented in the next section.

Application of System Theory to Uncover Knowledge Gaps of the National Standardization of Laos

After understanding the relationships above, knowledge gaps were explored by comparing ISO and DOSM. However, to understand the knowledge gaps more precisely, the national standardization of DOSM is first presented.

Figure 2 shows the national standardization procedure of DOSM. It does not clear the standard steps the same as the ISO's standardization. Despite showing the stakeholder its activities from the proposal, standard drafting by NTC, voting by NSC, and finally its publication, it does not define the resources required for each activity, such as guidelines, forms, laws, and policies. Each activity and process does not specify deadlines, undermining the stakeholder's ability to predict the next step and how long it takes to complete it. Additionally, onsite meetings for presentations, comments, and the two voting procedures by NTC and NSC require setting up appointments suitable for everyone involved. Consequently, forging a new standard in DOSM takes a long time, reflecting an inefficient process, which must be improved.

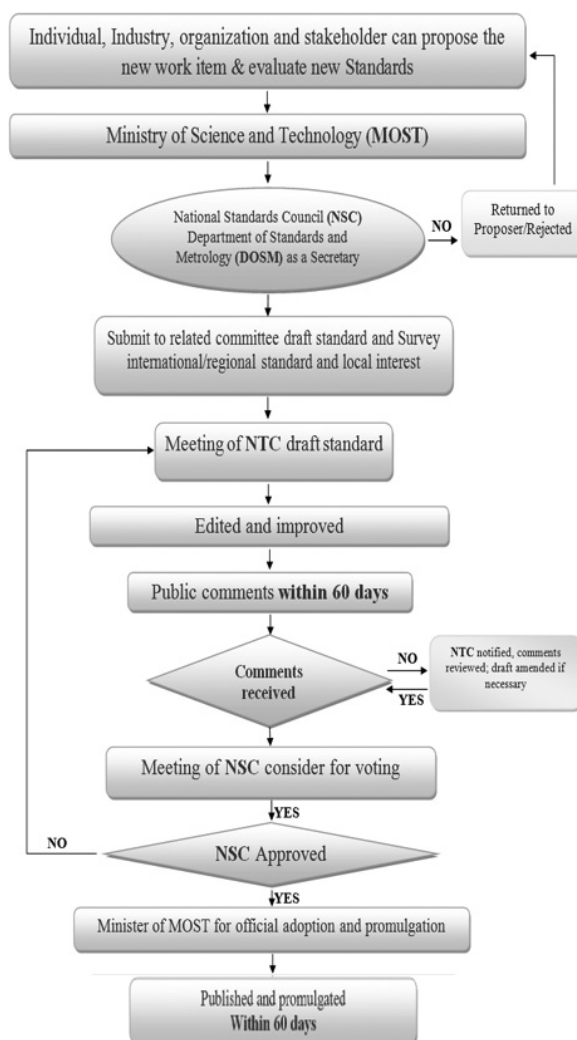


Figure 2 The national standardization procedure of DOSM, Lao PDR

Source: Standard Division (2021)

Upon careful, simultaneous comparisons and consideration between the two procedures, the standardization process in Laos indicated three knowledge gaps discussed further in the following:

Unpreparedness of the resources in the standardization stages

In Figure 1, ISO provided the resources necessary in every standardization step and classified them into twelve categories. However, DOSM merely indicates in all stages the essential resources in the form (F, text in underline). The ISO standardization process uses four forms in four steps: the Form 4-NWIP in the

proposal stage, the Form-Limit date extension request in the committee stage, the Form-Limit date extension in the inquiry stage, and Form 13-Report of voting on ISO/DIS, but DOSM utilizes only two forms in the proposal and approval stages. The DCS shows the officially appointed workgroups and how the consolidated supplements smoothly assist in implementing the activities. The EBP as a virtual voting tool supports a more secure and convenient voting process. Unfortunately, the DOSM does not provide the DCS and EBP, which are critical in the standardization process, because of its limited capacity in budget and lack of information technology (IT) personnel. Providing an online system requires significant financial resources for its hardware components, software, and IT specialists for service and maintenance. ISO utilizes guidelines in the preparatory stage since they are essential resources for a smoother standardization operation. It describes a step-by-step process of designing standards, including criteria, timing, and reporting. Additionally, it guides the users on solving problems that may arise during the process. Since DOSM does not provide guidelines to support its operation, problems arising during its standardization process may take considerable time to resolve.

Consequently, its standardization activities are less than the ISO's (underlined text in Figure 1). The DOSM should develop the DCS and EBP resources for its national standardization projects. Furthermore, it should create comprehensive guidelines, submission interfaces, forms, and other resources. DOSM should also be concerned with budget and IT technicians regarding procuring resources and improvement activities in the standardization process.

Lack of important activities in standardization stages

Comparing the number of activities in the standardization process, DOSM has significantly fewer activities than the ISO's (underlined text in Figure 1), especially voting, copyright, and patent issues. In voting, DOSM requires two, but ISO mandates four: voting in proposal, committee, inquiry, and approval stage. This frequent polling reflects a more reliable standardization process essential in making national standards. DOSM should therefore increase voting frequency in its process. Additionally, utilizing online voting should increase efficiency and convenience.

Additionally, DOSM does not investigate copyright and patent issues, which the ISO does. In a free-market economy, industries confront complicated copyright and patent problems. A standard designer who recognizes this problem daily becomes adept with the intricacies of the law and applies this valuable knowledge in his design. DOSM currently focuses on developing national standards and does not emphasize copyright and intellectual property activities as Laos' industrial scale is small and developing compared to Japan, Taiwan, and Thailand. However, suppose Laos's policy aims at the manufacturing industry for exports worldwide in the future, that requires international standards. In that case, DOSM must consider these issues inevitable.

The lack of these activities exposes the knowledge gap in DOSM's standardization processes. Moreover, the department should develop the conformity assessment to ensure the products' specified requirements and provide patent policy, copyright, intellectual law, and agreement services.

Need of creating the partnerships of standard organization

This idea came up when comparing the number of DOSM and the ISO cooperation partnerships. ISO has cooperated with world-leading standards organizations such as the ITU, IEC, and CEN. They collaborate to acquire more knowledge and skills in designing new standards sharing materials and equipment for their standardization process. In contrast, DOSM has meager organizational partnerships, mainly from the governmental sectors. Additionally, the DOSM headquarters has no ISO 17025 certified laboratory for testing and calibration. Although this certification is not directly related to standardization, it can support the standards designation regarding technical information and inspection. For example, in cases of testing or confirming some properties of a product, such can be done by its laboratory; however, without ISO 17025, this step will be for external organizations to analyze. This situation exhibits the limitation of DOSM to design new standards independently.

Therefore, the department must establish and expand its networks of stakeholders through internal and external cooperation, such as academic institutes, ministries, ASEAN countries, and other similar agencies. DOSM should sign agreements and cooperations with professional standards organizations such as the Thai Industrial

Standards Institute (TISI) and the Standardization Administration of the People's Republic of China (SAC). Moreover, it should constantly monitor and evaluate these projects and their implementation to strengthen its long-term cooperation with these partners.

Conclusion and Recommendation

In this review article, the author presented how to apply the system theory to explore the knowledge gap of standardization of the DOSM, Lao PDR. This exploration revealed three knowledge gaps: (1) unpreparedness of the resources in the standardization stages; (2) lack of important activities in the stages of standardization and; (3) need of creating the partnership of standard organization. These findings, implemented through a holistic and comprehensive understanding of the DOSM's situation, may systematically guide its standardization process development in the future. DOSM could plan and develop standard projects efficiently by considering consistent resources with activities in standardization steps, for example, providing a proposed guideline for stakeholders in the proposal stage and preparing a manual for the working group in the drafting standards stage. Also, DOSM should prepare resources to deal with problematic intellectual property and copyrights in the future.

Under limited resources, especially budget, DOSM should precisely plan and decide on projects, which resources to provide and acquire earlier and later, sequentially. In addition, developing standardized processes should be based on rational principles and the relationship between system theory and standardization. In using the online system to create standards, the department must consider several factors such as IT equipment, internet speed, IT knowledge, and skills of stakeholders, including the cost of maintenance and upgrading the online system.

However, this paper is limited to the standardization process rather than the inspection and certification of standard procedure.

Conflict of Interest

The authors declare that there is no conflict of interest.

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