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Implementation Barriers: A TASKS Framework

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Abstract Implementation is ubiquitous. The identification of barriers to implementation is critical for achieving implementation success. This paper introduces and discusses a deductive theory-based framework, TASKS, to guide the identification of implementation barriers. The **TASKS** framework deals with the relationships between a **T**ask and the task implementer's **A**ffect, **S**kills, and **K**nowledge, based on the inversed U-shaped mental **S**tress-mental effort relation. The TASKS framework classifies implementation barriers into four categories: 1) emotion barriers, 2) logic barriers, 3) knowledge barriers, and 4) resources barriers. The TASKS framework detects barriers to implementation following three steps, 1) identifying the ideal TASKS components, 2) modelling the implementer's mental capability, and 3) detecting barriers to implementation. The TASKS framework can be applied to a wide range of disciplines for effective and efficient task implementation.

Keywords: Barriers to implementation, task, mental stress, mental effort, mental capability

Implementation is ubiquitous. The word "implement" comes from the Latin "implore", meaning to fulfil or carry into effect (Murray, 1971). Implementation science is defined as "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice" (Albers et al., 2020). Hence, implementation science needs to solve a wide range of implementation problems (Peters et al., 2013). Overcoming implementation barriers is a central theme in implementation science. Identifying and overcoming implementation barriers can be seen in education (Ali et al., 2018; Berge, 2013; Milic Babic & Dowling, 2015), sustainability (Bianchini et al., 2019; Karji et al., 2020; Kirchherr et al., 2018), software development (Nelson et al., 2019; Vassallo et al., 2018), organization management (Oliva & Kotabe, 2019; Othman et al., 2021), and medicine (Albers et al., 2020; Bach-Mortensen et al., 2018; Fischer et al., 2016; Waltz et al., 2019). While most of the research in implementation science takes a bottom-up, inductive evidence-based approach (Bach-Mortensen et al.,

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2018; Waltz et al., 2019), we propose a deductive theory-based approach, aiming to model the cause-effect relations between influencing factors and barriers. Notably, we intend to classify implementation barriers and define the fundamental factors contributing to these barriers.

Implementation is an action. Action has its implementer and action object and requires resources. During the implementation process, the implementer is an individual or an organization (implementors), and the action object is a task. Thus, the implementation relies on implicit and tacit resources, implementer capabilities and the task context. An implementation aims to optimize the effectiveness and efficiency of actions within a specific context by overcoming barriers. In order to overcome implementation barriers, one would ask the following five questions:

- What is to be implemented?
- Who implements?
- What are the barriers to implementation?
- How to identify implementation barriers? and
- How to overcome implementation barriers?

This paper proposes a **TASKS** (**T**ask, **A**ffect, **S**kills, **K**nowledge, and **S**tress) framework to address the first four questions related to implementation barriers. The TASKS framework is based on two premises: first, humans perform the best when their mental stresses are at an optimal level (Yerkes & Dodson, 1908)**;** and second, human mental stresses depend on workload and mental capability that is defined by affect, skills, and knowledge (Nguyen & Zeng, 2012, 2017). The last question, overcoming implementation barriers, is the goal of behaviour changes, which will be discussed separately.

To describe the TASKS framework, this paper is organized as follows: Section 1 introduces the TASKS framework to define and classify barriers to implementation. Section 2 describes strategies and steps to identify implementation barriers. Finally, section 3 concludes this paper.

1. Implementation Barriers: Definition and Classification

1.1. What is to be implemented: Task

The implementation object is a task, namely a piece of work to be accomplished (Locke et al., 1981). Completing a task is similar to a problem-solving process, which involves four steps: understanding the task, producing candidate solutions to accomplishing the task, making decisions to select a good solution, and taking actions to deliver the selected solution (Zoller et al., 1987). Nearly all human activities can be considered tasks. Understanding a task formulates what needs to be implemented, which can mostly take the form of questions. Good questions can open up the opportunity of obtaining important information and digging deeper into a task (Flammer, 1981; Vale, 2013). Therefore, asking questions is a fundamental prerequisite to incorporating knowledge transfer priorities into task planning (Koch & Sauer, 2010). That is to say, asking questions is a vehicle to start a process of generating solutions that can lead to action (Vale, 2013). Hence, fundamentally, a task is to ask.

1.2. Who implements: "ASK" constitutes the implementer's mental capability

Human mental capability is the foundation to define implementation barriers. An implementation barrier represents human incapability to complete a task and increases mental stress. Based on the Yerkes-Dodson law (Yerkes & Dodson, 1908), which states an inverse U-shaped relationship between mental stress and performance, Nguyen and Zeng (Nguyen & Zeng, 2012, 2017) qualitatively defined human mental stress ($\boldsymbol{\sigma}$) as the ratio of perceived workload over mental capability, as described in Equation (1).

$$\boldsymbol{\sigma} = \frac{\boldsymbol{T}}{\boldsymbol{C_p}} = \frac{\boldsymbol{T}}{(\boldsymbol{K}+\boldsymbol{S})*\boldsymbol{A}}, \ \mathbf{A} \in (\mathbf{0}, \mathbf{1}), \quad (1)$$

where knowledge (K), skill (S), and affect (A) are three key factors determining the human mental capability (C_p) to tackle a perceived workload (T) related to a given task. The workload is an external load exerted on an individual. This workload can be associated with the complexity of the task. The amount of external workload is the most direct source of mental stress. Both knowledge and skills form human rationality. Knowledge (K) includes the facts and cause-effect relationships related to the workload (T). Skills (S) can be categorized into cognitive and affective, for which logic is a critical part. The activated knowledge and skills lead to the complementation of workload, yet the activation level may vary. Affect (A) refers to any experience of feeling or emotion, ranging from suffering to elation. Affect, which falls between 0 and 1, could determine how much of an implementer's knowledge and skills can be activated and harnessed to complete a given task.

TASKS framework is a generic model that is closely related to existing discipline-specific causal models. Wan et al. (Wan, 2021; Wan et al., 2017) proposed the KMAP-O casual framework for the behavioural system that constitutes Knowledge, Motivation, Attitude, Practice, and Outcome. KMAP-O framework suggests that health education or behavioural intervention(s) may directly affect knowledge, motivation, attitude, and practice to influence the outcome. Meanwhiles, suboptimal knowledge, motivation, attitude, and practice could become barriers that mediate the effect of health education or behavioural interventions on desired outcomes. Although the TASKS framework can be applied to a wide range of disciplines, it shares considerable similarities to the established implementation science framework in health research. Michie et al. proposed the Theoretical Domains Framework (TDF) of behaviour change at the implementer level to investigate implementation problems (Cane et al., 2012; Michie et al., 2005). TDF defined 14 domains of theoretical constructs that are related to behaviour change: 1) knowledge, 2) skills, 3) social/professional role and identity, 4) beliefs about capabilities, 5) optimism, 6) beliefs about consequences. 7) reinforcement, 8) intentions, 9) goals, 10) memory, attention and decision processes, 11) environmental context and resources, 12) social influences, 13) emotions, and 14) behavioural regulation (Atkins et al., 2017). Michie also proposed a casual behaviour system called COM-B involving Capability, Opportunity, and Motivation to produce behaviour. COM-B forms the hub of a "behaviour change wheel" (Atkins et al., 2017; Michie et al., 2011). Like the KMAP-O framework, TDF-related domains could act as barriers in the COM-B model to mediate the effect of behaviour interventions on behaviour change outcomes. At the organizational level, Damschroder and colleagues (Damschroder et al., 2009) proposed the Consolidated Framework for Implementation Research (CFIR) containing five major domains: 1) intervention characteristics, 2) outer setting, 3) inner setting, 4) characteristics of the individuals involved that might influence implementation, and 5) the process of implementation. Several domains in CFIR involve humans, therefore, human activities or tasks. In particular, the fourth CFIR domain is specific to the characteristic of implementers, which echoes the TDF domains and resembles the mental capability in the TASKS framework.

1.3. What are the barriers to implementation: inappropriate mental stress "Sigma (σ)" leads to barriers

Implementation barriers prevent humans from completing tasks (USAID, 2014). A direct consequence of implementation barriers is poor performance in completing a task. Yerkes and Dodson related performance to stresses (Yerkes & Dodson, 1908). In implementation science, the poor performance of the implementer is often associated with a lack of necessary effort. Nguyen and Zeng adapted the Yerkes-Dodson Law to address the relationship between mental stress and mental effort (Nguyen & Zeng, 2012), implying that an appropriate range of mental stresses will lead to optimal mental efforts. Low- and high-level mental stresses would produce low-level mental efforts, whereas medium-level mental stress results in optimal-level mental efforts (Figure 1).

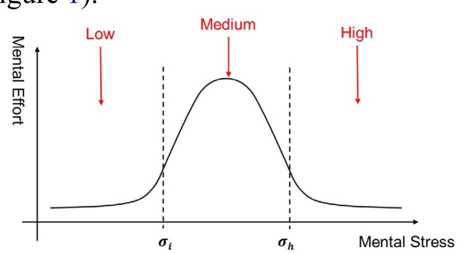

Figure. 1. Mental Stress-Effort Model

Suboptimal effort and its associated level of mental stress can generate implementation barriers. An implementation task is stated by the statement "Implementers implement a task". We can look for the sources of implementation barriers from the mental stress model presented in Equation (1) and other external resources such as time or cost. Then the statement is formed into "Implementers implement a task with their affect, skill, knowledge, and resources", as illustrated in Figure 2. We can then identify implementation barriers through identifying gaps between the actual and ideal human mental capability and resources to complete a task.

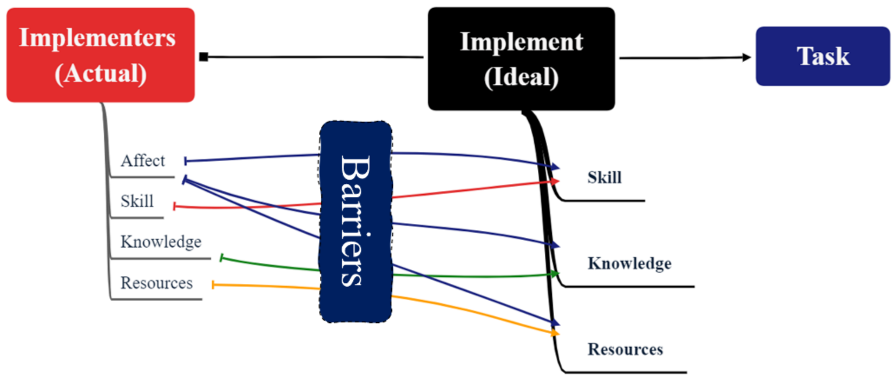

Figure. 2. The Implementation Barriers

Each of the affect, skills, knowledge, and resources gap between actual implementors and ideal scenarios could generate barriers to implementation. Accordingly, implementation barriers can be categorized into four sub-types: 1) emotion barriers related to the awareness associated with motivation, attitudes (such as cognitive/awareness, expectation, and value) (Rosenstock et al., 1988; Wan, 2021), belief (such as acceptance, optimism), feelings (such as anxiety, pressure, fear), or ethics; 2) logic barriers related to thinking styles (such as synthesists, idealists, pragmatists, analysts, and realists), thinking strategies and reasoning abilities; 3) knowledge barriers, including knowledge and actionability to accomplish a task; and 4) resource barriers related to all required implicit and tacit resources around the task environment. The classification is shown in Table 1.

Table. 1. Barriers Classification

Categories	Content
Emotion Barriers	Motivation, attitudes (such as cognitive/awareness, expectation, value), belief (such as acceptance, optimism), feelings (such as anxiety, pressure, fear), or ethics
Logic Barriers	Thinking styles, thinking strategies, or reasoning methods
Knowledge Barriers	Knowledge and actionability
Resource Barriers	All environment components (such as time, money and cognitive capacity)

1.4. Examples of barriers

The health domain is among the most researched area regarding implementation barriers. The primary methodology in health research is the evidence-based approach through qualitative and quantitative studies (Albers et al., 2020; Bach-Mortensen et al., 2018; Waltz et al., 2019). Qualitative studies conduct individual in-depth interviews or focus groups providing rich text data on individual and contextual determinants, whereas quantitative studies consist of administering surveys, questionnaires or experiments to quantify contextual determinants (Albers et al., 2020; Peters et al., 2013).

For example, implementation science in health research has identified a wide range of barriers to implement health-related interventions. Previous studies reported barriers that are specific to individual studies (Lawrence et al., 2016). As a comprehensive summary, Cochrane et al. (Cochrane et al., 2007) defined seven categories of barriers: cognitive-behavioural barriers, attitudinal or rational-emotional barriers, professional barriers, barriers embedded in the guidelines or evidence, patient barriers, support/resource barriers, and system/process barriers. Cognitive-behavioural barriers include lack of knowledge, awareness, professional skill, or appraisal skills. Attitudinal or rational-emotional barriers include lack of efficacy, lack of confidence, lack of sense of authority, lack of outcome expectancy, and inaccurate self-assessment. Professional barriers include the influence of invariants such as age, experience, gender, lack of motivation, the influence of individual characteristics, concern for legal issues, rigidity of professional boundaries, lack of appropriate peer influences or models. Barriers embedded in the guidelines or evidence include lack of practical access, lack of comprehensible structure, lack of utility, lack of local applicability, lack of convincing evidence. Patient barriers include conflicting culture, educational, cognitive, attitudinal behaviours, and lack of adherent or concordant behaviour. Likewise, Fischer *et al.* (Fischer et al., 2016) organized and summarized three main barriers: 1) personal factors related to physicians' knowledge and attitudes; 2) guideline-related factors related to the task and its instructions of the process; 3) external factors related to organizational constraints, tasks required resources, and interactions among other professionals. These barriers are mapped into the TASKS framework, as shown in Table 2. The TASKS framework has also been applied to other areas such as sustainable design, education design, organizational management, and design creativity (Nguyen & Zeng, 2012).

Table. 2. Barriers to Implementation of the Health-Related Interventions

Categories	Content	Barriers to implementation of the health-related intervention
Emotion Barriers	Motivation, attitudes (such as cognitive/awareness, expectation, value), belief (such as acceptance, optimism), feelings (such as anxiety, pressure, fear), or ethics	a. Motivation b. Attitudes: awareness, expectation, value, agreement, self-efficacy, leadership, judgement, creativity, outcome expectancy, adherence c. Belief: acceptance, optimism d. Feelings: uncertainty, legal, peer, gender, local culture, courage, confidence, anxiety, pressure, fear e. Ethics
Logic Barriers	Thinking styles, thinking strategies, or reasoning methods	a. Thinking styles: critical appraisal skills, b. Thinking strategies c. Reasoning methods: induction, deduction, abduction, recursion
Knowledge Barriers	Knowledge and actionability	a. Knowledge: awareness, familiarity b. Strong in language, specific professional knowledge (biology, chemistry, medical theories), clear intervention goals, c. Guideline (access, layout, complexity, applicability), social and clinical norms d. Actionability: awareness, familiarity e. Effective communication f. Accurate self-assessment, age/maturity of practice,
Resource Barriers	All environment components, time, money	a. Human environment: collaboration, cognitive capability b. Built environment: utility, local applicability, organizational constraints, resources (time, cost/funding, support, workload) c. Natural environment: genetic

1.5. Naming of the framework: TASKS

The proposed framework is named TASKS based on Equation (1), symbolically demonstrated in Table 3. Note that using the symbol σ to denote the stress is borrowed from engineering mechanics.

Table. 3. Naming the Framework: TASKS

a.	A task is to ask: **T**(o)ask
b.	**ASK** constitutes human mental capability: **A**(ffect), **S**(kills), and **K**(nowledge)
c.	Effect of completing a task: **S**(tress)
d.	**TASKS**: $\frac{T}{(K+S)*A} = \sigma \rightarrow \frac{T}{KSA} = Stress$ → T(KSA)$^{-1}$ =S → T(ASK)S

2. Detection of Implementation Barriers

This section describes the logical steps to detect implementation barriers as follow: 1) identifying the ideal TASKS components; 2) modelling the implementer's mental capability (ASK) guided by the ideal TASKS components through various quantitative and qualitative research methods; and 3) detecting the implementation barriers by analyzing implementer's mental stress through comparing ASK and the ideal TASKS components, as depicted in Figure 3.

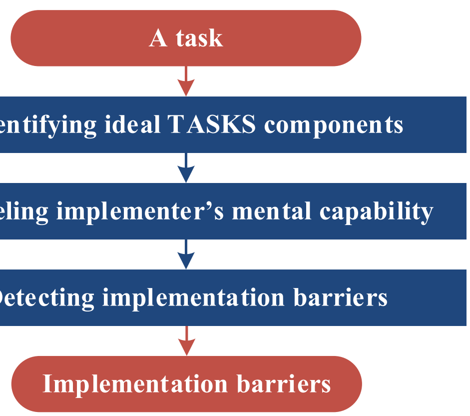

Figure. 3. Process to Identify Implementation Barriers

Notably, the first step is the key to the process, while the other two steps follow and contextually depend on the ideal TASKS components.

2.1. Identifying ideal TASKS components

Identifying the ideal TASKS components, as the foundation for detecting implementation barriers, aims to identify the workload and related knowledge and skills. Based on Equation (1), the ideal TASKS components can be identified following two steps: 1) workload analysis and 2) skills and knowledge analysis. Affect analysis is unnecessary for ideal TASKS components because no emotion would be involved in an ideal situation.

Effective implementation is achieved through implementing targeted goals and practicing them in the real world (Albers et al., 2020). Based on the life cycle of a task, workload analysis aims to define the critical workload and resources to complete the task. Each piece of workload can be viewed as a question, described in Section 1.1. The knowledge and skills analysis aims to collect the necessary and sufficient information to answer the question related to each piece of workload.

2.1.1. Workload analysis

The goal of a workload analysis is to define "who" is "to do what" with "what resources" to complete a task. The input of a workload analysis is a task description. The output is a list of questions with the necessary resources assigned to the specific task implementer(s), as shown in Figure 4. The workload analysis process is similar to that of requirements analysis for a design problem, where a task description can be viewed as a design statement (Wang & Zeng, 2009).

Figure. 4. Process of Workload Analysis

A task is an action object whose context makes up the environment components. The workload related to a task lies in the interactions between the task implementers, which is a part of task environment components, and the other task environment components throughout the entire life cycle of a task. Therefore, workload analysis can be conducted by analyzing the life cycle of a task, the environment components included in the life cycle, and interactions between task implementers and other task environment components.

The environment of a task is everything except the task itself (Zeng, 2015, 2011). Zeng and colleagues (Chen & Zeng, 2006; Yang et al., 2020; Zeng, 2020) define the task environment in three dimensions: life cycle events, life cycle time, and environment types (social, economic, built, and natural environment), as shown in Figure 5. In the context of implementation science, life cycle time might depend on the specific task and the task-specific context. A typical life cycle of a task includes the initiation, planning, implementation, monitoring, and closure (Westland, 2007).

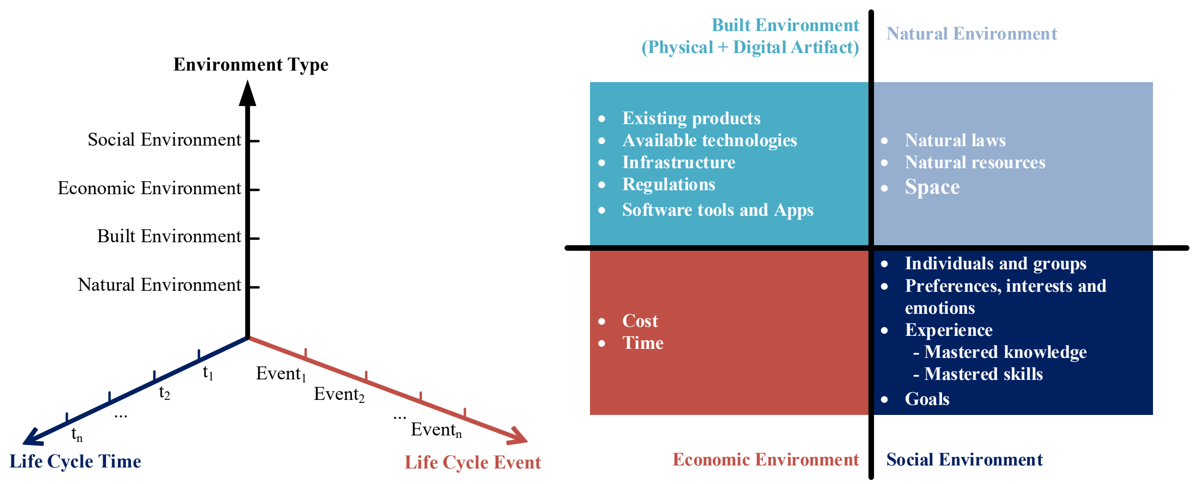

Figure. 5. Product Environment Structure (Yang et al., 2020)

A task description can be defined by multiple life cycle events, i.e., initiation, planning, implementation, monitoring, and closure in the TASKS framework. For each life cycle event, many sub-life cycle events form this task's workloads. Four environment types (social, economic, built, and natural) are analyzed for each sub-life cycle event, as shown in Table 4.

The relationship between sub-life cycle events and their environment components is "who is to do what with what resources to complete a task". The social environment forms the task implementers. Implementers need to detail tasks for each life cycle event. The workloads are analyzed through sub-life cycle events. Other environment components (social, economic, built, and natural) can be viewed as the source of task resources, as shown in Table 5.

Based on Table 5, a list of questions with the necessary resources assigned to specific task implementer(s) is shown in Table 6.

Table. 4. An Example for Task Environment Components

Life cycle	Sub life cycle events	Environment components
Initiation	Event 1	Social environment
		Economic environment
		Built environment
		Natural environment
	⋮	
	Event n	
Planning	Event 1	Social environment
		Economic environment
		Built environment
		Natural environment
	⋮	
	Event n	
Implementation	Event 1	Social environment
		Economic environment
		Built environment
		Natural environment
	⋮	
	Event n	
Monitoring	Event 1	Social environment
		Economic environment
		Built environment
		Natural environment
	⋮	
	Event n	
Closure	Event 1	Social environment
		Economic environment
		Built environment
		Natural environment
	⋮	
	Event n	

Table. 5. Environment Components for Each Life Cycle Event

Task life cycle	Initiation	Planning	Implementation	Monitoring	Closure
Implementer	Who				
Resources	Utilities				
Workload	Verb-Noun phrase				

Table. 6. A Workload for Implementers: Questions

Workload	Questions	Implementers
Verb-Noun phrase	5W1H	Who

2.1.2. Skills and knowledge analysis

Skills and knowledge analysis is the second step in identifying ideal TASKS components, collecting the necessary and sufficient information about each piece of workload. The analysis input is the workload and related questions, whereas the output is the ideal skills and knowledge required to tackle the workload by answering the questions.

In the TASKS framework, task, skills, and knowledge are interdependent. One way to investigate the relationships between task, skills and knowledge is to use logic, where skills are the way of reasoning. The task can be considered as the minor premise, and knowledge is the major premise of logical reasoning. Reasoning is the process of using existing knowledge to conclude, make predictions, or construct explanations. There are four types of reasoning (Zeng & Cheng, 1991): 1) deductive logic that starts with the assertion of a general rule; 2) inductive logic that begins with observations; 3) abductive logic that begins with an incomplete set of observations, and 4) recursive logic that combines deductive logic, inductive logic, and abductive logic. As a result, four different types of tasks (summarized in Table 7) can be defined according to the four types of logic: deduction, induction, abduction, and recursion (Zeng & Cheng, 1991). Deduction defines prediction tasks, which aim to predict the future based on the information provided in the task description and the existing knowledge. Induction defines generalization tasks, which aim to develop new knowledge from known evidence or collected knowledge. Abduction defines diagnosis tasks, which focus on finding causes from given effects by applying the proper knowledge. Finally, recursion defines the design task related to situations where the task goals, knowledge, and task solutions are interdependently evolving. Therefore, ideal skills and knowledge can be assigned to specific questions, as shown in Table 8.

Table. 7. Ideal Skills and Knowledge Required to Tackle Workload

Task type	Skills	Known knowledge	Required knowledge
Prediction (Deductive)	For a T, $\dfrac{p(T) \quad p(T) \to q(T)}{q(T)}$	$T,\ p,\ p \to q$	q
Generalization (Inductive)	For a T, $\dfrac{p(T) \quad q(T)}{p(T) \to q(T)}$	$T,\ p,\ q$	$p \to q$
Diagnosis (Abductive)	For a T, $\dfrac{q(T) \quad p(T) \to q(T)}{p(T)}$	$T,\ q,\ p \to q$	p
Design (Recursive)	Find a T, $\dfrac{q(T)}{p(T) \to q(T) \quad p(T)}$	q	$T,\ p,\ p \to q$

Table. 8. Skills and Knowledge to Questions

Workload	Questions	Task type	Required resources	
			Skills	Knowledge
Verb-Noun phrase	5W1H	Table 7	Cognitive and affective skills	Domain knowledge

2.2. Modelling implementer's mental capability

The second step to identify implementation barriers is to model the implementer's actual mental capability to complete the implementation task. The outcome of this step is the workload perceived by the implementer and available resources, together with the implementer's affect, skills, and knowledge. The fundamental problem for good modelling of implementer's mental capability is to extract a structured model from often unstructured implementer's behaviour data. This problem can be solved in a tEEG framework proposed by Zeng's group (Feng & Zeng, 2009; Jia & Zeng, 2021; Zhao et al., 2020).

As such, an implementer's TASKS components can be identified following three steps: data acquisition, data segmentation and coding, and data analysis, as shown in Figure 6. Data acquisition aims to acquire the data related to the implementer's task. Data segmentation and coding aim to structure the unorganized data and quantify the qualitative data. This type of data analysis aims to model the implementer's mental capability related to a given task.

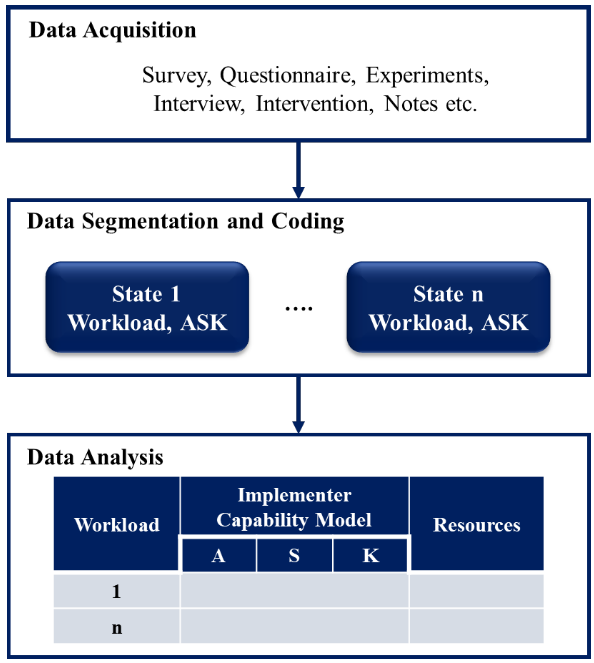

Figure. 6. Process to Model Implementer's Mental Capability

2.3. Detecting of implementation barriers

The detection of implementation barriers is to detect the four categories of barriers (Table 1) related to a task workload. The input are the ideal and actual TASKS components. The output is knowledge barriers, logic barriers, emotion barriers, and resources barriers, which are gaps between the ideal and actual TASKS components. The process of detecting implementation barriers is shown in Figure 7.

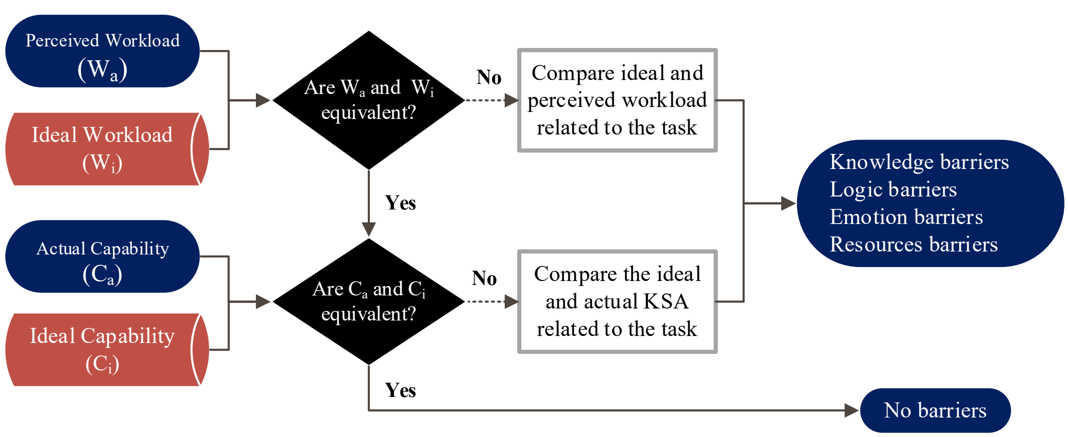

Figure. 7. Process of Detecting Implementation Barriers

3. Summary

We propose and define the TASKS framework for implementation science to detect implementation barriers and classify them into four categories: 1) emotion barriers, 2) logic barriers, 3) knowledge barriers, and 4) resources barriers. The TASKS framework is founded on the mental stress-mental effort model. The TASKS framework is 1) a deductive theory-based framework for effectively and efficiently identifying implementation barriers; 2) a holistic framework that is constituted by workload, affect, skills, knowledge, and resources for task implementers; and 3) a proactive framework that naturally integrates task requirements within the implementation process. The TASKS framework consists of three steps: 1) identifying the ideal TASKS components, 2) modelling implementer's mental capability, and 3) detecting implementation barriers.

Though the conventional inductive evidence-based approach could reveal implementation barriers through rich qualitative and quantitative behaviour data related to a task implementation, the deductive theory-based approach can model complex real-world behaviours using only a few primitive concepts defined in the TASKS framework. Thus, this framework is promising in detecting causes that lead to success or failure in task implementation with the support of a minimum amount of data. The future work includes developing methods to overcome barriers and applying the TASKS framework to various disciplines.

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Yong Zeng is a professor in Information Systems Engineering at Concordia University, Montreal. He is also an Adjunct Professor in the Department of Community Health Sciences at the University of Calgary. He is the President of the Society for Design and Process Science. He was NSERC Chair in aerospace design engineering (2015 - 2019) and Canada Research Chair in design science (2004 - 2014). Zeng researches creative design by developing and employing mathematical and neurocognitive approaches. He has proposed Environment-Based Design (EBD), addressing the recursive nature of design and the role of mental stress in designer creativity. He applies the EBD to the aerospace industry, medical devices, human resource management, municipality, teaching and learning, and health.