Addressing Factors Towards Human-Centered Technology

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ABSTRACT

University students were reported more stressful than others at any other stages in life. A major reason of stress among students is due to the presence of excessive information or known as information overload. The individual's cognitive style is one of the factors that leads to information overload, which influence the individual's information searching behavior. This has been recognized by a preliminary study, conducted to nine (9) postgraduate students in Universiti Teknologi MARA. A semi-structured interview had been completed and the result showed that 67% of the students suffered information overload during information searching activity due to lack of searching skills to filter information. 78% of the students suggested to have a well-organized browser (structured information and searching flow) to assist their information searching activity. Based on Technology, People, and Process (TPP) approach, any IT system should harmonize three (3) key components: Technology, People and Process to ensure better performance or solution. Therefore, a literature analysis had been done with respect to the research context and the result showed that there is possibility of relationship between technology (human-centered), people (information processing), and process (information searching) components. Finally, it could answer the research question: how to design a better technology solution for people through information searching mechanism to reduce information overload.

Key words: Cognitive Styles, Information Overload, Information Search, Human-centered technology

1. INTRODUCTION

It was reported that university students were more stressful than those individuals at any other stages of their life [1][2]. The major reason of stress among students is due to the presence of excessive information that cause harmful effect on their performance [3][4]. Further studies by [5–10] indicated that the existence of excessive information is due to the characteristics of the individual itself. The individual's cognitive styles or psychological factor [11][7][10], that is the way they process, and communicate with the information leads the information overload problem to be occurred.

Information overload has been considered as a state in which the information processing requirement exceeds the limited human information processing capacity [12-18]. It can cause failure if there is imbalance between the information processing requirement and the information processing capacity [9]. The information received by the individual becomes a hindrance even though the information is potentially useful [19]. In this research, information overload has been defined as a perception on part of the individual that is the information processing requirement exceeds the information processing capacity which creates a degree of stress for which his/her coping strategies are ineffective.

Information overload can be happened to everyone, everywhere, at any time. The proliferation of information has imposed information overload to the individuals, organizations [6-7][16][20-22] groups and the society [16][22] if the issue is not being managed effectively. In line with this research, in previous literature, there were numerous authors reported that information overload problem is commonly happened on individual level that is postgraduate student [10][23-26]. Postgraduate students are a unique user group in information searching behavior studies. They are the generation who are most capable especially with their proficiency in using technology [27][3] and they are the heaviest users of online platform [64] to search for information.

The main reasons for information overload can be related to several factors. Information overload occurred not because of a single factor but a mixed of five main factors such as human factor, information factor, task/process factor, organisational design factor and IT (technology) factor [5] [7-8][10] [28-29]. In this research, information overload has been explored on the individual's level that is on human factor, technology and process/task factor. The rationale of looking at technology, people and process factors is based on result from preliminary study that have been conducted to nine (9) postgraduate students age 24 – 45 years old. From the finding, 67% admitted that they experienced information overload during information searching activity as they did not have skills to filter information. In addition, 78% agreed to have a

well-organized browser (e.g. structured information, searching flow) to assist their information searching activity. From the result, it shows that technology, people and process factors should be integrated to get effective solution in reducing information overload.

In addition, to overcome the effects of information overload on individual, today's trends have generally resorted to technological solutions such as intelligent agents, semantic technologies, business analytics, and recursive machine - learning to assist individual in filtering the relevant information from the non-relevant via technologies [16]. The existing solutions seem to focus on technological means rather than exploring the use of people in managing the information [30]. As reported by [30], there is existing research proposed to investigate the coping mechanism of humans, yet the holistic human component of the relationship between technology and information overload remains under - researched. [3] remarked that successful implementation of any systems depends on integration of technology, people and process. Technology is facilitated by people and is supporting the processes to run smoothly or to make the work efficient [32][33].Thus, this research objective is to identify the relationship between people, process and technology components that can reduce information overload problem among postgraduate students. This research referred to Technology, People and Process (TPP) approach to achieve the objective.

2. LITERATURE REVIEW

2.1 Existing solution to information overload (IO)

Previous studies highlighted the five (5) factors that contributes to information overload are technology, people, task/process, organization and information [5-10]. In this research, researcher has decided to focus on three (3) factors due to findings gathered from preliminary study, that is technology, people and process. The examples of studies were tabulated as in Table 1. Table 1 represents the factors and existing solutions to information overload problem among students or individuals.

According to Table 1, there are three (3) factors of information overload among students which include technology, people and process/task. Variety of solutions had been proposed to solve information overload issue. However, most of the existing studies proposed solutions based on a specific factor. That is, information overload due to technology factor had been solved with technological solution, while information overload caused by people factor had been tackled by the people itself. And, information overload due to process/task factor had been handled by improving the process. Lack of solutions which integrate people, technology and process factor to solve information overload problem among students. As indicated by [42];[43], the three (3) components which is people, technology and process should be harmonized to improve performance. Therefore, there

were several studies had demonstrated an effort to propose solution that link between two (2) components either process and technology [29][5], or people and technology [29][5][40] to solve information overload problem. Furthermore, there is study by [37], introduced a solution which integrate the three (3) components. Nevertheless, it is in bigger context whereby the proposed solution (framework) can be referred by information user, information architecture and information professionals. It is not specifically related to student's needs during information searching activity. However, the general idea by [37] can be used as a guidance for this research on how to integrate the components to produce better system or effective solution to information overload problem. Besides, the previous studies were mostly focused on specific factor and solution to information overload, less emphasis on the process or task involved in their studies. This research focuses on information searching process as it was highlighted during preliminary study where the students were overwhelmed with information during the information searching process. They did not know the proper way to control the information searching process until they experienced information overload.

Table 1: Factors and existing solutions to information overload

IO Factor	Study	Element	Solution
Technology	[10][29][34][35]	• Technology advancement	• Policy on appropriate use of technology • Training or code of practice on technology • Filter system • Auditory feedback to provide information • Intelligent agent – personal assistant to search information • Transactive memory system to detect human behavior
	[29]	• Poor integration • Over reliance on technology	• Work with the Soft Science Professionals, engineers, Computer Expert and Accountant • Hire technology coaches and information mentors
	[36]	• Usage perception	• Customize technology based on gender characteristics
	[37]	• Information presentation on system	• Information Architecture (framework)
	[38]	• Information systems • Data access	• Tools – spam and email filter • Intelligent agent
	[5]	• Various channels for the same contents • Push system • Speed of access	• Intelligent information management • Prefer push- to pull-technologies • Intelligent data selectors (intelligent agents) • Systems that offer various information organization options (e.g. filing systems) • Natural language processing systems (information searching)
	[39]	• Frequency of use • Multitasking • Distraction with notification	• People action to remind on the risk of excessive technology use
People	[34]	• Push and pull information	• People action - control push and pull information
	[29][10][5][38]	• Level of experience • Motivation • Training • Education • Attitude and satisfaction	• People action - Proactive and reactive strategies (prevent and react) • Tools for time management and personal information management • Training for information literacy
	[40]	• Information management abilities	• Increase information literacy – use tools or techniques to support people
	[37][5][39]	• Information processing capacity • Information literacy	• Apply Slow Principles to control the activity and the context, with a reflective attitude • People action – improve information literacy
	[7][38]	• Cognitive styles	• People action – time management and information literacy
	[3][41]	• Psychological/ psychological ill-being	• provides refined knowledge to online healthcare providers and the organizations managing health websites
Process/ Task	[29][7][10][38][5]	• Task complexity • Task novelty • Task interruption • Multitasking (too many tasks) • Unclear goal of task • Time pressure • Too detail standard	• Handle activity once • Discontinued periodical activity • Limit or reduce time on any activity • Remove undesired activity • Give attractive tasks • Standardize operating procedures • Collaborate with information specialist • Collaborative tools for cognitive support
	[37]	• Nature of task/process	• Apply Personal Information Management (PIM) tools to study the person activities to complete tasks

2.2 Technology, People, Process Approach

In organization, there are many approaches which are followed for organizational management. The most popular is Technology, People, Process (TPP) approach [44]. In this research, TPP approach is used as it is related to research context. TPP approach considers an IT system is based on the fundamental belief that Technology, People and Process are the three (3) key components of any successful IT organizations. These three components need to be addressed for organizational improvement [44] and to have a good system, as information system is seen to be an essential key for organizations [72]. Table 2 represents the TPP approach with example for each component [31-33].

Table 2. Technology, Process and People (TPP) approach

Component	Study	Description	Example
Technology	[32]	Tools and techniques used to communicate and to make work efficient. Technology is facilitated by people and is supporting the processes to run smoothly.	• Information management systems • Architectures, • Hardware and software
	[33]	Tools and technologies that support the activities of the people to enable them to achieve their potential and empower them to excel	• ICT infrastructure – Technology infrastructure consists of hardware devices, operating systems and middleware on which the information systems run.
	[31]	IT that is used as part of a broader system encompassing people and process	• Platform • Supporting technologies
Process	[32]	A set of interrelated work activities.	• a set of specific inputs and value-added tasks that make up a procedure for a set of specific outputs [7]
	[33]	Process is a logical sequence of tasks performed to achieve certain objective.	• Business rule - a statement that aims to influence or guide behavior and information in an organization E.g. mandate, policies and guidelines
	[31]	A set of activities in a system enabled by people in the organization	• KMS process – Creation, Storage/Retrieval, Transfer & Application
People	[32]	Right time, right place, right people equals success. Human that improves the process	• Those who knows what & how to perform activities • Right skills & knowledge • Motivated & engaged to high performance • Who are encouraged to improve
	[33]	Right people, right time to do the process.	• Skills • Practices
	[31]	Those who use the IT and process to ensure successful implementation of a system.	• Attitudes, motivations, and the interpersonal behavior of the individuals within systems

In Table 2, it can be summarized that these three key components are related to each other. In a system, people need to complete a set of processes, these processes should be done systematically, thus technology is needed to support the process to run efficiently. Hence, any IT systems should integrate these components to ensure better performance or solution for their organization.

3. RESEARCH METHOD

This research use literature analysis methodology [76] [77] in order to get the overview of the selected topic, and to identify the gap in previous study. The literature review process involved throughout this research are 1) selecting review topic, 2) searching the literature, 3) analyzing and synthesizing the literature and 4) writing the review. The detail about the process is presented in the following subtopics.

3.1 Selecting a review topic

In this step, the researcher has conducted a preliminary study to nine (9) postgraduate students from Universiti Teknologi MARA to confirm on the issue. The selected issue is information overload since it was continuously reported in the previous literature. The semi-structured interview has been completed to postgraduate students which consists of six (6) parts: demographic, phenomenon, causes/factor, symptoms, effects and coping strategies. Result from interview showed that students experienced information overload during information searching activity.

Next, the researcher skimmed few books and articles in the selected field that is Human Computer Interaction and IT infrastructure in the context of information overload. After that, the researcher read the topics to develop familiarity with the keywords. In this research, four (4) keywords has been identified: information overload, information searching, human-centered technology and cognitive style.

3.2 Searching the literature

Based on the keywords, the researcher further the process to search and select appropriate articles. Literature search is undertaken from year 2014 until 2019 by using electronic database. The most used online databases that are related to this research such as Emerald insight, IEEE, Google Scholar, ACM Digital Library.

In Emerald insight database, information overload term returns 3000 hits, in ACM information overload term returns 471 hits, while in Google scholar, hits reach to 41 300. In addition, IEEE hits 1640 result for information overload. Furthermore, for information searching term in student's context, Emerald insight returns 39 000 hits, ACM returns 14 807 hits, Google scholar returns 118 000 hits, and IEEE returns 98 hits. It shows that information overload issue during information searching is quite common and has been studied by many disciplines.

Besides, for cognitive style term, Emerald insight returns 9000 hits, ACM returns 20 044 hits, Google scholar returns 40 900 hits, and IEEE returns 569 hits. Cognitive style is one of the human characteristics that is well established in previous studies. For human-centered technology term, Emerald insight returns 5000 hits, ACM returns 117 758 hits, Google scholar returns 49 000 hits, and IEEE returns 796 hits.

In general literature search, the result of hits gives an overview that this topic is well established in most disciplines. The researcher has to analyze and synthesize the topic to see the gap for future research.

3.3 Analyzing and Synthesizing the literature

In this phase, researcher analyze the collected articles. The researcher read the summary or abstract to get sense of what the articles are about. At this point, the initial classification and grouping of articles is done based on scope of research. The information overload articles have been grouped based on technology, people and process factors as these factors are the most common among students. Synthesis matrix is used based on Technology, People, Process (TPP) approach (Table 1 and 2). From this matrix table, gap of the existing studies can be seen where technology, people and process factors were not integrated to produce effective solution to information overload issue.

3.4 Writing the review

The literature is organized started with introduction to research topic, main body of the research and finally conclusion that provide the summary of the research finding.

4. RESULT AND DISCUSSION

The result from preliminary study give a viewpoint for the potential of technological solution for students through information searching mechanism to reduce information overload. From nine (9) postgraduate students, 67% admitted that they have problem during information searching activity while searching for information via search engine. 78% of them stated that they would be interested to use a system that could assist them during information searching activity. This initial finding reveal that the postgraduate students concern on technology (system) that can reduce their information overload problem.

Furthermore, based on literature review, as technology, people and process components are important in any systems, therefore, the discussion regarding these components are presented in the following section (4.1 – 4.3) to see the clear connection between the components within the context of this research.

4.1 People component: Cognitive Styles (Information Processing)

According to previous studies [31-33] as in Table 2, people play important roles to use the technology provided in order to improve the process. Hence, it shows that human factor is important that can potentially affect the interaction between

human and computer [45]. There are many human factors such as cognitive styles, gender differences and prior knowledge [45] have been discussed. Among them, cognitive styles are consistent across domain and seen as a stable characteristic over the time [46-48]. Cognitive style describes differences in the preferred strategies for information processing among individuals [45][47];[49].

In previous research, cognitive styles have been highlighted as a psychological dimension representing consistencies in an individual's manner of cognitive functioning, particularly with respect to acquiring and processing information [50][47];[51]. Individuals have different cognitive styles that influence the way they process information [52], and their performance [53];[54]. In this research, the student's cognitive styles have been explored as it is proven to cause information overload to them [7][38].

Regarding to [55][54];[56], 30 models had been reviewed and conclusion had been made whereby cognitive styles could be organised into two *orthogonal* dimensions that is a Wholist-Analytic dimension (WA) and a Verbal-Imagery dimension (VI). WA dimension is the way material is structured, while VI dimension is the way information is represented. For example, when information is presented in wholes or in parts, with or without a content map [57][58]. It is believed that WA cognitive styles also have an impact on search behavior and search performance [59];[11] but few studies have been done in this direction [59]. Table 3 illustrates the WA cognitive styles dimension (holist-serialist family) which focus on information processing construct.

Table 3. Cognitive style and information processing element

Construct	Study	Cognitive Styles Dimension	Element	Description
	[47] [54] [57]	Wholist (Holist)	• Whole/Integrated/ Global	• Structure information as a complete whole • Individual process information as a whole
Information Processing	[47] [54] [57]	Analytic (Serialist)	• Part/Separated/ Local	• Structure information in parts • Individual process information in discrete part

Table 3 indicates the WA dimension which focus on information processing construct. The focus element for WA dimension is integrated and separated. These elements clearly show the way people process information as a whole or in part which will influence the way they search for information either specific or general search. As stated by [60], information searching skill is in some respects related to individual's cognitive styles.

4.2 Process component: Task Complexity (Information Searching)

Individual plays a role in influencing information overload. Information overload that happened to individual is influenced by education, training, [10] motivation [29][7][10]

and psychological makeup of the individuals itself [10-11][61][29][7]. This research focuses on psychological of the individuals since it was reported by [62] as the psychological consequences of information overload can have severe implications at the individual levels. Stress is reported as the most common effect felt by sufferers of information overload [62]. This is due to inability to manage information where confidence and searching skills are important. Without these skills, it is easy for individual to become overwhelmed [62].

In the area of information search, cognitive styles were found to impact people's search performance [46];[11]. Information search is a very complex process, involving many cognitive and behavioral factors [59]. Information searching behavior consists of all interactions with the system, whether at the level of human computer interaction (HCI) or at the intellectual level, which it will also involve mental acts, such as judging the relevance of data or information retrieved. In the current study, information searching behavior is defined as stages and activities where a user primarily searches and retrieves information on the Web; subsequently, he/she organizes information, and finally uses it for particular purpose [63].

In this research, students will be bombarded with tasks at different level of complexity (advanced and basic) to monitor their information searching behavior during experiment session. When students look at the tasks given to them, they will process the information and search for information according to their processing styles, either integrated or separated. Then it influences them to use either 1. Top-Down, Broad strategy or 2. Bottom-Up, Narrow strategy during searching (Table 4). At this moment, students will be monitored on information overload experience.

Table 4. Cognitive style and information searching element

Construct	Study	Cognitive Styles dimension	Element	Description
Information Searching	[47] [57] [60]	Wholist (Holist)	• Top-Down • Broad Strategy	• General to specific information search • Breadth-first path, high usage of OR operator to link keywords, more truncation
	[47] [57] [60]	Analytic (Serialist)	• Bottom-Up • Narrow Strategy	• Specific information search, high usage of keywords • Depth-first path, high usage of AND operator to link keywords, less truncation

Table 4 describe the WA dimension with information searching construct. In previous studies, lack of attention given to information processing and information searching constructs among students. Information processing and information searching constructs are related to each other. Students behavior during information searching are based on their information processing styles. Therefore, this research focus on these two constructs as well as to support the preliminary study whereby students experienced information overload during information searching phase.

[40];[5][7] agreed that information overload issue is usually caused by the person itself. To tackle this issue, it relies largely on the individual's ability that is the way individual handles the information searching process [40]. By taking control of individual information environment, it can avoid the effect of information overload and allow him to control the information searching process at his greatest satisfaction [40]. Taking control of the individual searching process by understanding why individual stop information search. It is important especially in the online environment context since in many cases an individual could conceivably search forever and may leads to information overload. As stated by [64], the search process is terminated at some point when the user judges that he has enough information to move to the next stage. To make this judgement of sufficiency, the user invokes stopping rules.

In reducing the implication of information overload, skills need to be increased and an emphasis is placed on technology as a tool [65]. Generally, information technologies are known as to shape the way people accomplish their work [66]. Therefore, in today's trend, technology becomes the main solution to information overload problem [62]. Technology which focus on human factor.

4.3 Technology component: Human-centered application

The use of technology is growing very fast [71] and it has brought a lot of benefits to people nowadays. By 2030, technology will be entangled into everyone's lives. The trend is expected where technology will work as an extension of people, to manage and automate day-to-day activities. Therefore, people's need is significant to be met [67]. The technology element is composed of tools, applications and infrastructure that make processes more efficient [68];[69].

From the front-end user point of view, the application is important component which consists of web browsers, word processors, mail client etc., and it is typically run on front-end user devices such as PC's, laptop, etc. [70]. Therefore, any improvement should be tackled on application component as needed by front-end user to ensure better performance. As indicated by [73] human-centered system is designed for human use. The focus of human-centered system is to ensure the efficient and effective of human performance.

Human-centered system refers to a design that is based on the psychological and physical needs of the human [73][74]. Human-centered design is an approach for designing a system that is physically, perceptually, cognitively and emotionally intuitive [75]. Thus, in this research, cognitive style is considered as it is a stable human factor to be studied. And cognitive styles are proven to influence information searching activity based on the tasks given to students. The information searching strategy used by students is expected to lead for

information overload problem. Therefore, a cognitive coping mechanism will be studied in the nest research to control the searching activity to reduce information overload.

According to [75], ISO 9241-210 has specifically recommended six characteristics of the human-centered design:
1. The adoption of multidisciplinary skills and perspectives
2. Clear understanding of users, tasks and environments
3. User-centred evaluation driven/refined design
4. Consideration of the whole user experience
5. Involvement of users throughout design and development
6. Iterative process

In this research, 2nd characteristic (clear understanding of users, tasks and environment) has been applied whereby the human characteristics (information processing), and task characteristic (task complexity) is been detailed out to see the connectivity between three (3) components: technology, people, and process.

From the finding, it could be concluded that technology, people and process are important factors and should be integrated to have a better solution. Thus, for the purpose of this research, Figure 1 depicts the research model based on synthesized literature review. As shown, we propose that technology, people and process should be connected to solve information overload problem.
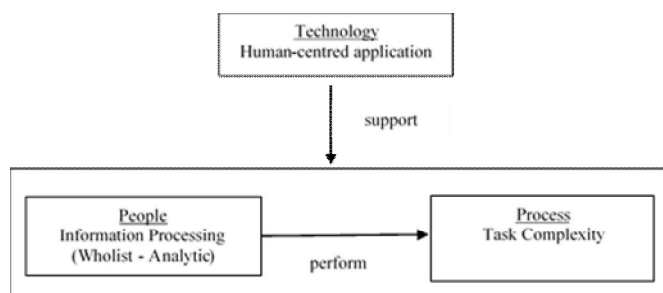

Figure 1: Research model

Figure 1 illustrates how the human centered technology will help student's information processing styles through a set of tasks given to students via information searching activity in online platform. The integration of these three (3) components is believed to improve the student's performance when information overload problem is reduced then leads to decreasing in stress level.

ACKNOWLEDGEMENT

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