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Research paper



Exploration of Factors That Influence Information Security Education

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Abstract

The improvement of knowledge is very important in information security domain. due to its positive effect on users' information security education. It is acknowledged that security education is playing a vital role to mitigate the risk of information security incidents and breaches that faced by users through their ordinary life. Although several approaches have been proposed in information security education, yet these threats continue to increase. To assist the effort of information security education, this research explores the effective factors that have been used in the approaches of information security education, investigates the gaps, and hence, proposes new factors that can help to developing an effective approach to information security education.

Keywords: *Effective factors, information security education, knowledge retention, memory structure.*

1. Introduction

Information security is becoming a great concern to both computer and Internet users, who are suffering from an assortment of information security threats daily, whereby there are millions of incidents caused by virus, spam, spyware, phishing and many other threats of information security [1]. Those incidents are having severe effects on the community and economy [2], through causing the loses and damages to users in different institutions and sectors. Moreover, those threats can influence any kind of users in terms of behaviour and cognition. Understandably, information security involves both technology and people, and it is becoming increasingly evident that the human is the major factor in information security [3, 4]. Even though several information security approaches have been developed, the state of information security is getting worse [2]. Irrespective of how well designed and which techniques are used, security approaches drawing on individuals to be implemented and used. Therefore, these approaches may not achieve their intended purposes when they are not used appropriately [3]. Besides, many people are often hesitating to use some applications due to their worries about security threats [5], and thus people are prone to use various applications based on the span of what they were taught or understood about information security rather than the information security level. Therefore, enhancing users' knowledge plays a fundamental role to decreasing the risk of information security incidents.

Whitman and Mattord in their book entitled Management of information security, on page 189, stated that security education is one of the three ways to enhance security by building in-depth knowledge, as needed, to design, implement, or operate security programs for organisations and systems [6]. In addition, they differentiate information security education, training, and awareness, as described in table 5.3 on page 190 of the book [6].

Furthermore, higher education institutions are one of the targeted sectors via information security threats [7, 8], and the efforts are being made to enhance users' knowledge about information security whether during formal education or approaches development. However, few approaches have proposed to increase the user's knowledge of information security threats in higher education institutions [8,9,10,11,12]. This research will explore the factors affecting information security education in the previous approaches.

The following sections in this paper would be organized as follows. In section 2, we look at the related works conducted by other researchers. Section 3 involve a discussion and evaluation of information security factors in the previous studies. Section 4 outline the implications of memory structure in information security education, which will lead to the proposal of education factors in information security in section 5. Finally, the conclusion will be in section 6.

2. Related Works

According to [9, 10] the human is the main factor to mitigating information security threats. The study that was conducted by Majid [9] found out that the security awareness factor affecting security threats mitigation, while other factors influenced in security awareness factor itself are age, gender, and perception. Moreover, the study showed that the age factor affects on information security threats, whereby the senior respondents have 1.18 times more awareness than freshmen respondents. Consequently, the senior students have more awareness on security threats in e-learning compared to freshmen students. Concerning the gender factor, male respondents have 1.24 times more awareness compared with female respondents. Thus, male have more security awareness than female students in using e-learning system. Stu-

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dents' Perception factor was positively affected the security awareness factor, whereby increase of good perception indicates to the increase of security threats awareness. In the same context, other set of factors have been employed by the examinations management team to ensuring that the examination paper preparation process (EPPP) is secure [10]. These factors included the risk list, and the security controls list. The factor of risk list is guiding the examination management team to identify comparable risks and to prop a risk assessment effort executed by the management team. Concerning the factor of security controls list, it is used to identify security controls that maybe executed to protect the examinations papers as well as improve security of the EPPP. Both of factors positively influenced the mitigation of the risks are consistent with other studies [10]. Furthermore, according to [11-13], they stated that security training is a vital factor effecting on reducing of security threats. Based on the study that conducted by Ning [11] in designing information security training program for undergraduates, they found that ubiquitous learning factor could positively influenced the training program in information security classroom. This factor has been applied by the researchers in handling some issues pertaining to training program based on traditional information security classroom, such as, the lack of acquired knowledge related to information security threats due to time and space constraints of the traditional training program. In addition, Abraham [12] in her research employed the training strategy as a factor affecting security task performance, this strategy is based on component display theory (CDT), persuasive fear appeal messages, and constructivist learning theory. the results of this research disclosed that the training strategies utilized affect the effectiveness of the training program. The CDT-centered training participants exhibited higher changes in reported self-efficacy, short and long-term performance, behavioural intention as well as training satisfaction. Moreover, the author examined other factors that positively affected individual security task performance such as affective factors, which included self-efficacy, attitudes, behavioural intention and training satisfaction. Furthermore, another factor has influenced information security education investigated by Sharma and Sefchek [13]. The researchers found that the active learning using a hands-on approach is very effective factor in teaching security courses. In addition, this factor enhanced retention over a longer period since students perform the security tasks. Ultimately, the following table summarizes the factors effecting information security education utilized in previous approaches.

Table 1: Exploration of the factors that contributes to effects on information security education

Researcher	Factors	Security approach
Majid [9]	Awareness factors • Age • Gender • perception	Security awareness
Mogale [10]	Awareness factors • risk list • security controls risk	Security awareness
Ning [11]	Training factor • ubiquitous learning	Security training
Abraham [12]	Training factors • training strategy (component display theory (CDT), persuasive fear appeal messages, and constructivist learning theory) • affective factors (self-efficacy, attitudes, behavioural intention and training satisfaction	Security training
Sharma and Sefchek [13]	Training factors • active learning using a hands-on approach	Security training

3. Discussion and Evaluation

As previously mentioned, earlier researches focused on some factors that could be taken to reduce information security threats as shown in figure 1. One example is the study that was conducted by Majid [9] showed that factors such as age, gender, and perception influenced information security awareness of security threats. In addition, the study explored the relation of these factors with security awareness factor. Even though the study outcomes presented positive effects for those factors, the obtained results were based on participants' background or opinions using survey method. Besides, focusing on awareness approach only is restricted to focusing on drawing the attention of students about security threats, whilst security education should be focusing on acquire and retain knowledge that pertaining to developing an understanding of the reasons for security threats and how to cope with it, by employing instructional or innovated method. Subsequently, using appropriate factors may support the process of information security education. Furthermore, other awareness factors include risk list and security controls risk that provided by Mogale [10]. The identified factors are used to enable the examination management team in identifying and handling the potential risks during preparation of secure examination papers. The gap here was as the same as the previous approach, whereby the researchers focus on the security awareness level only by the awareness factors that guides to mitigation of the risks and neglect the security education facet that builds the understanding of information security threats in terms of the reasons and how to handle it. In addition, these factors are intended to be used particularly to prepare a secure examination paper. There is an imperative need for utilize a new approach that provide more effective security education, that enable people from acquire and retain the needed knowledge relevant to security threats, with employing of suitable factors to achieve that. Moreover, ubiquitous learning factor based information security literacy training has been used by Ning [11] to highlight the important issues that are complicated to be fulfilled by adopting the conventional training program due to time-space constraints. Notwithstanding, the evaluation method for information security knowledge was obscure and unclear. In addition, other aspects may ensure effective security education such as improvement of knowledge acquisition and retention are ignored, even though these aspects are essential to build a good understanding of security threats. Furthermore, the study of Abraham [12] investigated the factors that influence in information security training program in order to perform a security task. The factors component display theory (CDT) and constructivist learning theory were effectively employed to design training program, whilst other factors such as persuasive fear appeal messages, self-efficacy, attitudes, behavioural intention, training satisfaction as well as component display theory (CDT) were influenced the security task performance. Understandably, the effects of these factors are examined in terms of performance of security task only, which is consistent with training program purposes. Dialectically, very important aspect in information security education that need to be examined how people realize the information security knowledge, such as acquire it, and retain it when they need it. Moreover, Sharma and Sefchek [13] investigated the factor of active learning using a hands-on approach. The evaluation of the effectiveness of this factor was through performance of security task based hands-on method, which required specific equipment and training as well requiring a particular understanding to accomplish the training's stages, another issue is the assessment of this factor drawing on only performing the security task. These criteria often restrict and debilitate the approach effectiveness. Unlike what security education should be, which focusing on insight and understanding information security knowledge, taken into account the factors that assists to achieve that.

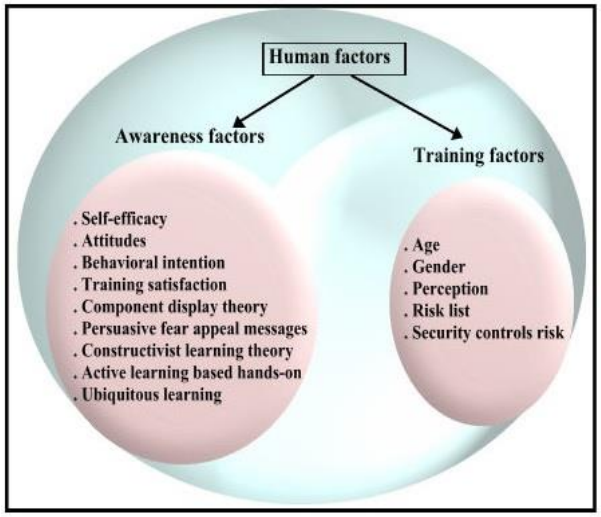


Fig. 1: Human factors in the previous approaches of information security.

Furthermore, the memory can play a significant role to solve such as issues since it has a robust relation with learning, whereas learning is a process of acquire new knowledge, while memory refers to the retention of that knowledge for future use [14]. Based on memory structure, people learn new knowledge and put them into their memory. In addition, people recall their prior knowledge from memory to relate with new knowledge, to make new knowledge meaningful, and in order to learn it effectively. Thus, the knowledge to be learnt should be processed through the memory. Which in turn, has idiosyncratic structure that its components synergy to coping with any complex information. Besides, by having a good understanding of memory structure is helping to determine the type of knowledge that it intended to be learnt or understood as well as how, which enable to developing much more efficiently and systematically learning.

4. Implication of Memory Structure in Information Security Education

The memory structure in brief, shows that it includes processes, types, and systems or stages (see figure 2). On the other hand, concerning memory processes, these processes represent encoding, storage, and retrieval. All three of these processes determine whether something is remembered or forgotten [15]. Encoding is the acquiring process and transmitting information so that it can be located in storage [16]. Storage involves holding the information so that it can be used at later time. Storage provides a link between encoding and retrieval [17]. Retrieval is the process of recovering earlier encoded information from storage so that it can be used to make decisions as well as solve problems [16]. According to [18] the knowledge is stored consecutively, and the core factors in retaining a higher proportion of knowledge lay in the transmission of information into memory systems or stages which are; sensory, short-term, and long-term memory. Moreover, An [19] have clarified that sensory memory (SM) involves information that derives into the brain through the senses devices. Short term memory (STM) which is also known as working memory (WM), it refers to mental tasks in which a small amount of information can be retained over a brief period [20]. In addition, the capacity of STM is limited [21]. Rehearsing can help keeping the knowledge in STM at longer time. For example, when people iterate a new person's name over and over to themselves, they are rehearsing it and retaining it in short-term memory [20]. Furthermore, a technique called chunking can assist to increase the capacity of short-term memory by combining small items of knowledge into bigger, familiar items [21]. Lastly, according to Wang [22] the information that rehearsed several times in STM is transferred to long-term memory (LTM) and vice versa. In addition, LTM has a roughly unlimited capacity and duration. For this reason, knowledge in LTM is deemed to be in permanent storage. However, limitations to LTM exist in terms of memory loss and forgetting [19]. Furthermore, the two main types of memories are classified into procedural and declarative memory [23, 24]. The procedural memory is a type of memory that is based on unconsciously storing and retrieving knowledge [25]. Frequently, it was applied in learning of new motor skills [23]. For example, learning on how to drive a car. In fact, one does not need to consciously remember how to drive a car, he will simply do it. Whilst declarative memory which requires conscious recall, whereby, it consists of knowledge that is consciously stored or retrieved [25]. In addition, declarative memory recalls of factual knowledge such as dates, words, events, and concepts [23].

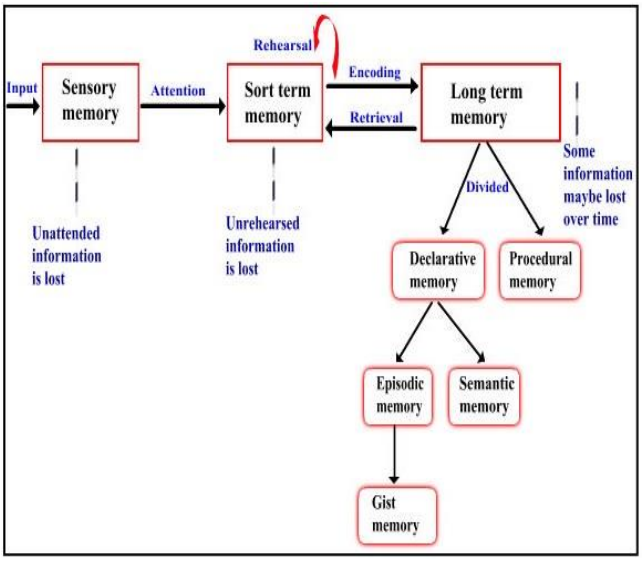


Fig. 2: Memory structure.

In higher education, declarative knowledge and long-term memory can plays a significant role in developing the academic achievements, due to the ability of LTM to store huge amount of accumulated declarative knowledge for a longer time. The acquired declarative knowledge in specific curriculum is referred to as a foundation for further understanding and study in that curriculum, as well as in other curriculums. In this case, the synergism between STM and LTM may influence the process of learning, since the students acquire knowledge during the lessons through STM, and the knowledge will be forgotten unless it is saved in LTM. Thus, the retention of knowledge acquired during official education is of vital factor to ensure more effective learning. Moreover, using some techniques with STM can increasing the knowledge retention in LTM, whereas using techniques such as rehearsing and chunking can assist to increase the capacity of STM, which in turn facilitate the transmission and knowledge storage into LTM. Thus, using of memory reinforcement instruments can be an important factor to increase the knowledge retention. Furthermore, the knowledge that has a stronger, and deeper meaning can be stored simply in the brain, and therefore helping the students to retain that knowledge. Thus, meaningful knowledge can be an effective factor to increase knowledge retention. As a type of declarative memory, gist memory can increase effective knowledge retention, since it possesses the ability to capture and retain the meaning of knowledge [26, 27], moreover the gist memory is long lasting, due to its stability over the time, and its resistant to intervention caused by adding new knowledge.

The knowledge in the memory can be elaborately manifested through memory models' studies, such are multistore model of memory [28, 29], and working memory model [30]. Both of them are important to manifestation and understanding the complicated mechanism to effectively input and output. Besides, how learning process is interacting with memory structure. Concerning multistore model of memory, this model serves the stimulus to analysis

the memory sophistications from the perspective of information processing. Not only that, the model offers a clear separation in the processes that is pertinent to retention, which therefore greatly helping to improve the learning. Whilst working memory model allows humans to temporarily store and manipulate knowledge while performing cognitive tasks. This model focuses on STM in details, it consists of several components responsible for specific short-term memory functions, which has a great role to boost the knowledge retention through classification and organization the functions of transmission and storage the knowledge into and from LTM. Therefore, using such as these models can influence the processes of knowledge acquisition and retention. Moreover, the memory can be enhanced through strategic educational methods, such as cognitive multimedia of learning theory (CMLT), which it represents a set of principles that can assist to achieve of the memory enhancement in instruction, one principle of such as multimedia principle states that, people learn more deeply from words and pictures than from words alone. In fact, the process of adding words to pictures is not effective way to achieve multimedia learning, and is such that, processes should be consistent with how human memory works to ensure effective successful learning. CTML can help to solve this issue. According to Mayer [31], the cognitive theory of multimedia learning, which consists of two channels (auditory and visual), three memory stores (sensory memory, working memory, and long-term memory), and three cognitive processes (selecting, organizing, and integrating). Based on this theory, meaningful learning from words and pictures occurs when the learner engages the cognitive processes. These cognitive processes mapping into working memory pinpoint which information is selected or attended to, which knowledge is retrieved from LTM and which information integrated with the new information to construct new knowledge, and eventually, which fractions of new knowledge are transmitted to LTM. consequently, the CTML can be an effective factor to instructional design that lead to enhance memory in education.

5. Five Effective Factors in Information Security Education

As shown in Figure 3, this research proposes five factors that can be influenced in information security education. The factors were based on memory studies, which include memory structure, models, and cognitive theory of multimedia learning, whereas, the factors start with the integration of short and long-term memory to build and understand the meaningful knowledge. Hence, both of them is a vital factor to acquire and retain the information in effective way. Particularly, the factor of gist memory that has the ability to capture and retain the meaning of knowledge, deeper meaning can be stored simply in the brain, and therefore helping the students to remember that knowledge. In addition, the proportion at which students forget or retain knowledge also rely on what method is applied to measure forgetting and retention. Moreover, memory reinforcement instruments can be a significant factor to acquire and retain knowledge. For example, an instrument such as digital storytelling can be used for the reinforcement of the memory. In addition, it possesses the ability to promote the retention of a long-term memory.

Therefore, the abovementioned factors can be integrated to effectively assistance the knowledge retention. Which in turn, has a significant role in education, since the purpose of learning is mostly to retain information beyond the range of a few minutes [32]. Finally, based on the previous factors, cognitive theory of multimedia learning can be an important factor that represent a link between learning and memory. It provides a guide to design and implement efficacious cognitive strategies that assist learners to learn more efficiently, through organizing the processes of learning using multimedia, in order to make them consistent with memory structure.

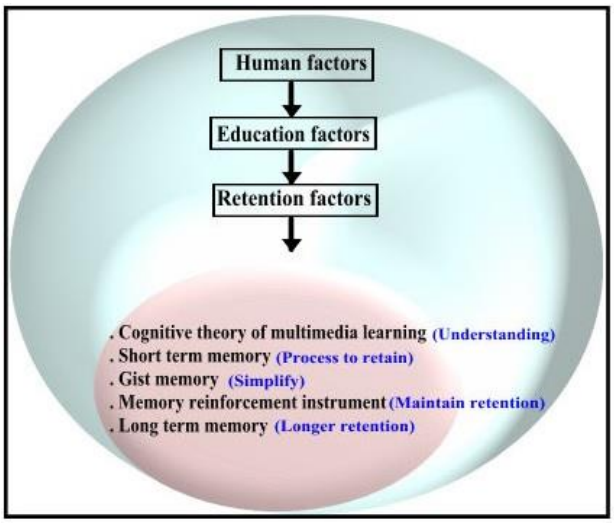


Fig. 3: Effective factors in information security education.

6. Conclusion

The output of the research is expected as effective factors accepted by users for security education applications. The effectiveness of computing environment is an important framework in order to gain the public's confidence in security applications in their daily learning transactions. On the other hand, it is also an important consideration for education community to provide their users with effectiveness and interactive system. This research highlights the factors that may influence the information security education, based on the integration of memory structure and models, cognitive theory of multimedia learning, and security needs. procedures and processes will allow improving knowledge retention in order to enhancing of the users' knowledge, with full ability to educating them about information security. This research is expected to serve as a benchmark for institutions to adopt and implement security applications.

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