

## Relativity Among Germane Load of CLT & HCI in Reading Tasks – A Review

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**Abstract**— According to cognitive load theory reading can be involved with three kinds of cognitive loads as name intrinsic, germane and extraneous. Among these, Germane Load refers to the use of relevant supportive material in par with various cognitive schemas to facilitate the reading & learning process. Thus, Human Computer Interaction phenomenon has become a key to this research area. There has been limited research conducted in this regard, and effective handling of germane load has been a research challenge. This paper reviews the concern and relativity on Germane Load in Human Computer Interaction specifically in reading tasks and the selection of the papers for the review being done through filtering topics of research papers taken from ACM Digital Library. The review of selected papers emphasize on some effects which generated by Cognitive Load Theory in reading. Out of them Work Example Effect plays a major role with HCI. Also this paper suggest an improvement in Human Computer Interaction to accommodate Germane Load effectively for reading purposes..

**Keywords**— CLT, HCI, Germane Load

### I. INTRODUCTION

Cognitive Load Theory (CLT) differentiates among cognitive loads of three types that occur in working memory during learning. The first cognitive load can be known as intrinsic cognitive load which emphasize on the major intricacy of information that is to be learned. It is based on the interactivity of reading or learning elements. As second type of cognitive load, extraneous cognitive load, is instigated by an inappropriate presentation of the learning material or by requiring learner to perform activities that are immaterial to learning. The final type of cognitive load is germane cognitive load which results from active structure construction processes and is accordingly advantageous for learning [1]. CLT has become a sub field in Human Computer Interaction (HCI)

[2]. Most of research in HCI are done with related to extraneous cognitive load and intrinsic cognitive load. Most of those researches done over the cognitive load theory is concluded to minimize the Intrinsic load because the intrinsic load of a no vice user will be very high therefore it is advisable to reduce the intrinsic load over reading and learning materials [3]. Also, when it comes to extraneous load that will be about the extra or unnecessary information place on the reading material which leads the user to experience long learning curves related to the content. Extraneous load is also advisable to be reduced and this will be directly influencing the reading & learning process, ultimately the learner [4]. But the germane load is encouraged to be increased especially in instructional reading and learning designs because that will recall the prerequisite of the user related to the task. Germane load will enhance the self-explanation effect and imagination effect [5]. Even though the research done so far emphasize that germane cognitive load needs to be promoted, it is ambiguous how to do so in reading materials [6].

### II SURVEY DONE PRIOR TO THE REVIEW

A literature review was conducted to investigate the amount of which Germane Load of CLT applied obviously in the research of HCI. Before going into detail with the review a filtering has been done through an informal survey. The Guide to Computing Literature database which of the Association of Computing Machinery (ACM) has been used for this survey. Approximately this database contains more than 1,500,000 credentials from more than 5000 publishers, including books, journals, proceedings of conferences, dissertations of Doctoral studies, Thesis of postgraduate studies, and technical reports. The survey was conducted using the terms “Germane load” as well as Cognitive Load Theory. Only the results in journals, books and conference proceedings were taken into consideration. Forty-Seven credentials contained “Germane load” in their papers as an abstract or in their caption. The other articles

encountered publications containing “Cognitive Load Theory” in their papers captions. The 47 publications were taken for further investigation based on the effective Reading, HCI and cognitive load.

### III RESULTS

Thirty nine Articles referred to the design of educational materials were selected as the major group.. There were few observable sub clusters as: 05 publications dealt with hypertexts .07 papers focused on learning with worked examples, 03 publications dealt with cooperative learning. Germane cognitive load was clearly described by 15 publications. Moreover it can be identified that all three types of cognitive load included in many ways into HCI literature. Out of them extraneous cognitive load seems to be the main concern. The research questions of 24 publications were similarly describing about the germane cognitive load and only 15 of them have relations with balancing intrinsic and germane cognitive load fostering germane cognitive load or.10 publications were stating on multimodal user interfaces and out of them the modality principle preserved a noticeable part. At the same time, it is obvious modality effect and split attention effect are intertwined with each other and they both raise the extraneous but can be used to foster the germane load. Also it appears that when the split attention effect and modality effect is seriously engaged with poorly designed reading materials redundancy effect takes place.

Based on this survey it was possible to figure out the fundamental tenets of CLT, relativity between CLT and effective reading, the effects caused by CLT while reading and learning and in what terms HCI ties with CLT. The rest of the paper provides further clarification on these areas.

#### A. Fundamental Tenets of CLT

According to Westbrook & Braver, CLT is an amalgamation of Intrinsic, Extraounus and germane Loads. According to psychological concerns, the cognitive effort required when learning a new task is addresses by cognitive load theory [7]. De Jong says that the CLT theory emphasize that obtaining new knowledge and expertise is easier if the kind of learning as well as reading instruction retains the load of cognitive, and because of this reason the memory demand on a user’s working will be low[8]. The intrinsic load fallouts from an interaction amid the amount and type of the material being learned and the proficiency of the learner [9].

Extraneous load relates to the manner in which the material being learned is presented. But for handling the learned content and consolidate them into new representations or enhancing existing ones germane load is needed [10].

Most of research done over the cognitive load theory is concluded to minimize the intrinsic load because the intrinsic load of a novice user will be very high [11]. Therefore, it is advisable to reduce the intrinsic load over reading and learning process. Also, when it comes to extraneous load that will be about the extra or unnecessary information place on the learning material which lead the user to experience long learning curves related to the content. Extraneous load is also advisable to be reduced and this will be directly influencing the reading material itself and the reader [12]. But the germane load is encouraged to be increased especially in reading and learning process because that will assist the reader to bring the prior knowledge into the memory of the user related to the task. This will enhance the abilities of imagining and self-explaining [13].

According to germane load theory, knowledge in long-term memory is stored in mentally created structures. Learning accelerates depends on the construction of schemata. A schemata can be defined as a single element in memory of working and then works to overcome the limitations of working memory. Furthermore, via schema construction, information can be processed without demands on working memory [14].As per Jong ,the conceptualization of the load of cognitive types has some counter arguments which criticizes its original assumptions. Out from all the general understanding is that germane load and intrinsic belong to two different ontological classes [15]: Intrinsic load refers to the difficulty of the studying of material, but the cognitive processes is referred by germane load. But refined definitions are there are of the three types of cognitive load and they emphasize the connections between the three different loads: Intrinsic load is modelled as processes of cognitive related to reading and learning task performances, with understanding as a type of specific performance. Germane load is associate with cognitive processes that go beyond simple task performance [16]. While inducing the task it provides a space in the memory of the reader to accommodate supportive structures which encourage reading. In that terms intrinsic load gives birth to germane load while reading and learning.

### IV EFFECTIVE READING & CLT

In the process of reading there are a number of collaborating variables involved that have attracted substantial interest over the past. When learners read a text they practice several cognitive procedures to process information which include repossessing and loading new inputs to the memory. To be able to process this information, they need to follow reading strategies to make sense and comprehend what they read [17].

The discipline of Cognitive Science emphasizes on CLT which an instructional theory is. It deals with the processes of reading and learning together with memory and problem solving. It designates the learning structures on terms of an information processing system which involves with long term memory. In reading the reader extracts information of the reading material and comprehend for proper interpretation [18]. If the reading information is novice to the reader the intrinsic load of the reader is very high and through a stressful process the reader tries to interpret the information. In such a situation the mental load and confusion will distract the ultimate objectives of the reader. At the same time reading and learning materials provide redundant information which confuse the comprehensibility. Also, if the reading material provides different pointers to the reader to locate reading supportive elements from different reading locations again it will complicate the reading task. This may lead for redundancy effect and split attention effect [19].

#### *A. Cousing effects of CLT*

Redundancy effects and Split attention and are just two problems arise with cognitive load. When the learners' attention is distracted by many unrelated elements when specific problem is focused by them, split attention effect occurs [20]. As an example, the main task of the learners' is to realize the sense of the material which they are reading, but they spend a lot of time with analyzing the structure of the verdicts or remembering the new words in the passage, therefore their attention is unfocussed and split attention effect is generated [21]. What means by the Redundancy effect is when learners are solving a specific problem, their focus is distracted by some extra information. While assimilating the irrelevant information, redundancy effect is produced [22]. Meanwhile the reading process, referring frequent to the dictionary or looking up in many other sources, interfere with schema acquisition. Modality effect also generates the extraneous cognitive load because when the reader seeks more sources for the comprehension multimodal designed needs to be

engaged with the reading process. These effects leads to create different reading habits and patterns.

#### *B Reading and Learning patterns*

When reading the reader is always focusing on the particular word and loos the concentration on the sentence. Even though, they try to analyse the structure of sentence throughout reading, which distracts their concentration on the comprehension of the meaning of the text and through that split attention effects take place [23]. This can be considered as the reason why after reading they only can remember randomly some new words and a few sentences. Split attention effect always seems to be increased the cognitive load. Readers are wasting their cognitive resources on some words, rather than aiming on the meaning of the whole sentence. Another reason is, when readers reads long sentences with a couple of new words, no matter they are significant or not, they tend to read the sentences repeatedly in order to have a complete understanding. Here they are not aware, and they do not understand that while recurrently reading these sentences, their cognitive resources are wasted. At this instance redundancy effect takes place [24]. This kind of effects of redundancy originates from the readers own reading habits and believes.

There are reading materials with various writing methods or passions also there are various readers with different reading styles. So here readers must find the correct reading style to understand the content of the reading materials and the learners can focus on different parts according to their reading goal. Practically in reading, some of the relevant information can be neglected, particularly sometimes a couple of new words or some insignificant sentences may get the concentration when the purpose of reading is for meaning [25]. In most of the time, if the reader feels that he understood the meaning of the sentence the task seems to be satisfactory. If they are attentive in the texts, they can read in detail for another time. Chang, Lie & Tseng says generally in China, educationalists try in each way to tell the learners all the information they know by themselves [26]. That is the reason in educating, irrespective of in elementary school or even in college, teachers spend a lot of classroom time to clarify everything in detail, from each new words to investigation of the sentence structure, word to word interpretation of the entire entry. That is the reason that the learners demonstrate the tendency for perusing everything in detail. Plass & et all .. indicates that both educators and learners have no clue that this sort of

learning is wasteful as well as rather related to cognitive load [27]. Therefore, it is obvious the rapport between reading and learning process and cognitive loads of the reader or the learner. Based on cognitive load the inducement to reading will be highly effected if the kinds of cognitive loads vary to each other. With the evolution of digital arena most of reading materials are in the form of e content. These e-content brings with the instructional designs which incur human computer interaction. Therefore, automatically the concerns in reading and cognitive load applies to HCI as the comprehensibility of the reading material influence the cognitive load of the reader. So, it is inevitable to concern on the association between HCI and cognitive load theory.

#### V BRIDGING HCI & CLT

The borders induced by working memory is described by the CLT. As per the conclusive of CLT, cognitive dimensions of people are so limited therefore only limited processes can be processed by them can be processed simultaneously. When the information to be processed exceeds a limit, people are incredulous. Based on recent research website complexity has become related to extraneous cognitive load. At the same time Task complexity seems related to intrinsic load. As Intrinsic cognitive load depends on the material or the task itself it cannot be altered. And also, Extraneous cognitive load is unnecessary and can be diminished by adequate visual presentation and design of material. All these are in relation with HCI because the output always presented through an interface.

#### *A HCI & Load Theory of Attention*

Lavia and the colleagues has developed the load theory of attention [28] that could be a branch of CLT. In load theory of attention there are two ways that of discriminating attention. the primary is that the sensory activity choice mechanism, which implies that a private will ignore immaterial distractor inducements once he or she is below things of high sensory activity load. The second mechanism is that the active mechanism of basic cognitive process management that's required for rejecting immaterial distracters even once these are perceived (in things of low sensory activity load) [29]. Here, perceptual load means either that more information needs to be processed for the same task or that the task is more demanding for the same quantity of information [30]. Based on this observation, it is possible to properly infer that on users' visual attention and behaviour cognitive load can have an influence. At constant time the HCI presence can influence this behaviour. supported a look done on evaluating web site

complexness mistreatment eye pursuit technique in step with the psychological feature load aspects they need used a watch tracking metrics associated with users' cognitive activities and visual attention together with fixation length and fixation count. There, fixation data has been wont to live the eye that people have paid to stimuli. Fixation length and fixation count have taken as ordinarily used metrics to live attention allocation. Fixation length has mirrored the degree of excavating into the data. Longer fixation length has indicated issue in extracting data, or it means the item is a lot of participating in how. The fixation count has showed the whole range of fixations on a given object. Task completion time, that may be a live of users' task performance, has taken under consideration. within the analysis less time has indicated a lot of economical deciding and higher style interface. However, searching on-line is a lot of difficult. Saving time might not be as fascinating to on-line retailers on customers. on-line retailers need to retain the customers as long as potential on their websites, exposing them to a lot of product data [31]. The results of this analysis has shown that web site quality is qualified by task complexity on users' visual attention and behaviour. In detail, once users conducted an easy task, the task completion time and therefore the count of the fixation were at the height level on the web site with high quality, whereas fixation period wasn't expressively totally different on the websites with different quality. However, once users conducted a posh task on an internet site with medium quality, task completion time, fixation count, and fixation period were all at their highest level. The load theory of attention was wont to give the reason for the results. Wang & et all. Provide guidelines for website managers and designers to maximize users' visual attention [31][32].

#### *B. Usability Principles and CLT*

According to Kumar & Kumar J, the most usual method of evaluation of HCI systems has been think aloud based Usability Testing [33]. Usability testing has been conventionally used to measure the ease of use, competence, effectiveness, learnability, memorability and satisfaction of interactive systems[34]. Here mental models or schemas get created due to the previous experiences which user has gone through. With respect to this explanation in short term memory, the users make logic of the HCI interfaces by connecting the information from the bunches of data coming from sensual memory about the HCI tasks. At the same time schema and mental models from long term memory will be fallen aside [35]. Usability testing uses a detailed testing mechanism where real users, matching the intended descriptions of the stakeholders in the

design and they are invited to complete tasks on real applications. This testing also tries to measure the cognitive loads produced by the interface-based interactions, though in a hidden way [36]. It has been noticed that the behaviour of think aloud slows down when the cognitive load which caused by the task is increased. As this method used to incite data from short term memory of the user itself causes a load on the cognitive resources, authors of this research suggest that think aloud based usability testing cannot be an effectual method to measure the cognitive load caused by the task in case of serious tasks which causes heavy cognitive load[33]. It is therefore, suggested that new methods to be developed to get information on cognitive load caused by the system .

When bridging instructional design principles of CLT to usability principles, it seems that some CLT design principles have been applied in software designing in the same way [37]. This has put on specifically to the split-attention principle and the redundancy principle. When considering split-attention principle, if a requirements analysis in software design indicates that different fragments of information are related to each other and are required for the completion of a task, the user should not have to remember information from one part of the dialogue to another, which is a usability heuristic [38], as well as the application of Gestalt laws [39] would indicate that the pieces of information should be displayed in close spatial proximity. Theories and perceptions of HCI and CLT have shown comparable evolutions. Both had a strong focus on the reduction of irrelevant cognitive loads. The identical theories of cognition built the basics of both CLT and HCI [40]. When considering the germane cognitive load, CLT incorporated principles to substitute learning processes through increasing germane load, which consequently may lead to an increase in cognitive load [41]. Correspondingly, in situations of preparing applications for research and education in HCI proposed that it might be beneficial to build applications that are easy to use. This relates to the CLT principles designed to promote germane cognitive load, but also to some principles designed to reduce extraneous cognitive load, particularly the principle of worked-example [42] and the modality principle [43]. A reason for this may be that these principles are much more specific to the reading and learning processes. Most of the time it was obvious the relationships between Intrinsic load and Extraneous Load, Extraneous Load and Germane Load also the cross sectional cohesion among the three loads and causing effects.

### C. CLT effects to foster GL within HCI

According to the review done Figure 01 has been formulated to depict the hidden behaviors of various effects which causes through CLT in a reading or learning task. These hidden behaviours will influence the Germane Load during reading & learning processes.

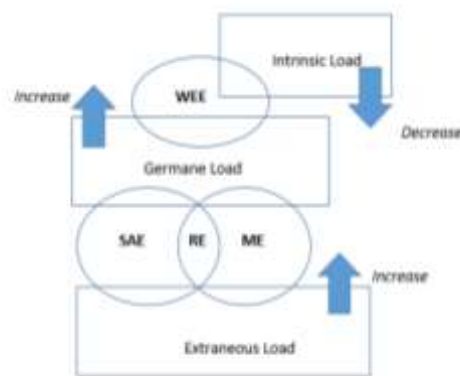


Figure.01: Considerable effects to foster Germane Load  
Source: Author

WEE –Work Example Effect      SAE – Split Attention Effect  
RE – Redundant Effect      ME – Modality Effect

Figure 01 clearly shows when the work example effect occurs intrinsic load of the reader decreases. That means the working memory load is optimized to increase the germane load which creates a space for different interpreting schemata in the memory of the reader. With respect to the split attention effect when the reading materials split the attention of the user for different comprehensible models modality effect will provide the means to present the same kind of reading information in different formations for ease of comprehension. This will increase the extraneous load and germane load too for better comprehensive reading. With this behavior HCI concerns can be amalgamated for improved reading practices.

### VI DISCUSSION AND FUTURE RESEARCH

It is obvious that Cognitive Load Theory is nevertheless considered in HCI research. Among the majority studies the emphasis on germane Cognitive Load is considerably low. But it is noticeable that there is a trend to foster germane load for HCI specifically for reading and learning tasks. In such a scenario Split Attention Effect and Modality Effect of reading and comprehension activities can be enforced positively on the readers' mental effort which increase the germane load.

As a reader expects to learn new things without too many newer things which loads the working memory HCI research can think of providing new schemata's to the reader with work example effect. Also the multi model interfaces can be encourage split attention effect positively while throwing new reading and learning schemata's to the reader. Eye Tracking [ET]and HCI research, Brain Machine Interfacing [BMI] and HCI research can highly contemplate about providing more user friendly reading materials while fostering germane load.

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