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Σχολή Θετικών και Εφαρμοσμένων Επιστημών

Μεταπτυχιακή Διατριβή
στα Πληροφοριακά Συστήματα

The correlation between user's cognitive abilities and web page perception in MOOCS.

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Η παρούσα μεταπτυχιακή διατριβή υποβλήθηκε
προς μερική εκπλήρωση των απαιτήσεων για απόκτηση

μεταπτυχιακού τίτλου σπουδών
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Summary

The problem that relies on the World Wide Web is the heavy load of information on web pages which causes a cognitive overload and therefore affects user's perception and ability to interact with web pages.

This study investigates the visual perception of an individual while interacting with online educational environments (MOOC websites). The objective of the study was to understand the user cognitive effort required when interacting with online educational environments and understand the relationship between web page visual complexity and user cognitive abilities in terms of their perceptual style (FD-I dimension).

This relationship was examined by classifying participants based on their perceptual style (field dependent and field independent) and perform tasks within websites that had different visual complexity. The visual complexity metrics had been calculated prior the run of the experiment with the use of visual complexity algorithm known as ViCRAM.

The correlation of time needed for a participant to complete the task within a webpage and the visual complexity score of that webpage, had lead the study to draw a variety of conclusions regarding how visual complexity affects each cognitive group. Moreover the study had collected quantitative and qualitative data that played a tremendous role in the understanding of this relationship. Another tool that had been used in the study and also helped grasp how the user interact within the examined web pages is the use of a special software that tracked the participants' mouse moves while searching for objects within web pages.

Based on all of the above the relationship between visual perception and visual complexity has been investigated. Valuable outputs have been produced such as a set of guidelines for developing less complex websites and a set of suggestions for the improvement of the complexity algorithm ViCRAM. It is also important to mention that because the study had to analyze a relationship inevitably a lot of aspects have been examined. For example some of the aspects that had been analyzed in the study are: website structure, coloring, font choice and font sizes, complexity of html elements, factors that affect complexity, difference between user's cognitive abilities in term of their perceptual dimension and investigation , use of mouse tracking devices and other aspects.

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Chapter One

1. Introduction

This thesis investigates the correlation of user's cognitive abilities in terms of perceptual style with their visual perception when browsing web pages. The cognitive abilities such as visual memory and visual attention are the two main pillars of this research aiming to enrich the framework of knowledge we already have in adaptive environment design with main focus of the research to rely on educational web pages. The problem that relies on the World Wide Web is the heavy load of complex web pages thus developing cognitive overload that affect user perception and his ability to interact with the web pages. This cognitive overload is very obvious in e-learning environments where they tend to convey more information than one can imagine, thus making the whole interaction process [92] more difficult. Most importantly, the information overload is inconsistent with the way a student learns and the amount of information one can process and therefore understand.

The purpose of the study is to understand the user cognitive effort required when interacting online with educational environments (web pages) and understand the relationship between web page visual complexity and user cognitive abilities in terms of their perceptual style (FD-I dimension). Cognition refers to the ability of the human mind to acquire and manage information [85], for doing so it uses different mental processes such as attention, memory, perception, problem solving and learning [86]. Additionally, it defines the trends as the manners in which humans approach, acquire, organize, process, interpret information [87] and how they use these interpretations to guide their actions [88].

In order to identify how the user interpret information the study will focus on three cognitive processes that are used [85] while human mind tries to acquire and manage information from a web page. Those process are: visual memory, visual attention and perception. Visual perception refers to a complex cognitive process by which the web page visitor/user extracts information-knowledge from objects and events in the environment and depends both on the stimulus and the individual's characteristics [89].On the other hand visual attention and visual memory are two cognitive process which seems to overlap [35, 36, 37]. Theorists claim that visual attention picks the information to be encoded and stores it temporarily into the working memory (visual memory), although others define attention in term of post-perceptual processing limitations [59, 60]. Moreover it has been alleged that these two cognitive abilities share a uniform set of process [59, 60].

The objective of the study is to investigate the association between cognitive abilities (visual memory and visual attention) and Web page complexity as it is perceived by the user / visitor when visits educational web pages, and specifically educational environments. More specifically the research will try to identify if there is correlation between visually complex Web Pages and Users cognitive abilities in term of visual attention. Web pages used in this study would be educational and specifically online learning courses, their complexity will be identified with the use of ViCRAM algorithm. The User's cognitive abilities in terms of their perceptual style will be classified based on the FD, FI and FN classification. Moreover a mouse tracking technology would be used to monitor user's interaction with the educational environments. All of the above contribute in study which aims to make a step further in understanding the user cognitive effort required when interacting with educational environments. Thus, it is significant to design an interface that reflects user's cognitive ability in terms of visual attention.

This research consisted of the following:

1. Identify user's cognitive abilities based on the Field Dependent – Independent classification.
2. Identify users' visual perception regarding web page complexity.
3. Run a user evaluation study where users will need to interact with the examined Web pages
4. Calculate Web page visual complexity with the use of an existing algorithm (ViCRAM)
5. Relate users perceptual style with the Web page complexity
6. Analyze Web pages' HTML DOM structure.
7. Evaluate the prediction and improve it by suggesting ways of incorporating cognitive abilities into the algorithm

1.1.1 Outcome of the study

This research investigates the factors either by the stimulus or the personal characteristics of the user that affect his perception; possible outcomes of the research are:

1. Identify the relation between cognitive abilities in terms of visual attention and visual complexity in educational environments. For example, identify how an FD user is affected by the environment in contrast with an FI based on the variables that would be examined.
2. Identify structural elements of a website that are more difficult for the user to understand them (ex. images, textures).
3. To identify layouts that are more difficult for the user to understand, it can be hypothesized here that nested layouts can be found more difficult for the user to identify them since an object can be a part of other objects.

In conclusion, this research expands the field of measuring and correlating the perceptual style of a user with the webpage perception due to complexity in educational environments. The field had received previous focus not only from the Computers Science sector but also from different scientific fields [5,6,22,23,24,25,26] (ex. Psychologists or other behavioral studies), nevertheless none of those studies have targeted educational webpages, as we know education is the backbone of the society. Therefore it can be speculated that such a study will offer great value not only for the HCI field but it can also have a significant impact in the processes by which the students (user of educational webpages) learn within the technological means provided today. Nonetheless, the study approaches the scientific area with main purpose of adding knowledge to the fields of: cognitive style, cognitive abilities, web perception and complexity.

Chapter Two

2.1 Cognitive abilities

People in their daily life need to perform simple tasks such as driving, talking, cooking or any other activity that a person need to do during the day . For a person to complete those tasks needs to have certain skills known today as cognitive abilities. The most fundamental abilities that a person can have to simply complete these daily tasks are: memory, attention, sensory perception and processing speed. Since people tend to be different from one to another it is inevitable that some people would be more gifted than others in terms of cognitive abilities. This difference between people however can be covered since cognitive abilities can be improved based on training [1] these gains are alleged to be present 5 years after the original training [2]. Therefore it can be alleged by this study that by identifying the cognitive style of an individual the study would be able to suggest web interfaces that would be more close to each learner, therefore less effort would be needed from the user for perceiving it.

Generally cognition refers to the ability of the human mind to acquire and manage information [85], for doing so it uses different mental processes such as attention, memory, perception, problem solving and learning [86]. Additionally, it defines the trends as the manners in which humans approach, acquire, organize, process, interpret information [87] and how they use these interpretations to guide their actions [88].

The success of this study in identifying the cognitive abilities of the individuals would not be only in benefit of the individual learner but also can work as an addition in the existing framework of knowledge in the HCI field. Developers can use the data derived from this study in coexistence with similar ones to provide web pages that enables interaction for individuals with different cognitive abilities. To achieve the above the study must correlate the cognitive abilities with the individual's web perception of webpages. Now for this correlation to be valid there comes the need of using variables that would provide the study metrics that eventually can be used for comparing individuals cognitive style. Such a variable can be the time completion task, where an individual search within webpages in a specific time period for an object, from this procedure it can be alleged that the user can be categorized based on their cognitive style based on the time completion and interaction path. The assumption on which the experiment will test participants states that a field dependent user will spend more time searching for an item in contrast with a field independent user. This first experiment will give to the study a categorization of users based on their cognitive style (HFT test). Moreover, a second experiment will run where users will evaluate educational web pages through questionnaires. The second experiment will be used to identify user perception towards the inspected webpages. Finally the data by those two experiments will be correlated along with ViCram algorithm which would provide in the study indications of complexity based on crawling and analyzing the webpages.

2.2 Cognitive Style

Cognitive style represents the distinctive way of functioning shown by individuals in their perceptual and thinking behavior during the decision-making process [94]. Moreover, it describes the tendencies as the modes in which students approach, acquire, organize, process, interpret information [95, 96] and how they use these interpretations to guide their actions [88].

The cognitive style of a user can be classified based on the individual's reliance on the context to extract particular meaning. The field of dependence-independence (FDI) lies within the most broadly studied of a variety of cognitive style dimensions appearing in the literature and especially in the educational technology field [93].

During the years many scientists tried to define cognitive styles with studies having different point of views inevitably there is debate in the definition of cognitive style. Goldstein and Blackman [112] define it as "a hypothetical construct that has been developed to explain the process of mediation between stimuli and responses. The term cognitive style refers to characteristic ways in which individuals conceptually organize the environment [112]."

Additionally, Goldstein et al [112] describe cognitive style as an information transformation process whereby objective stimuli is interpreted into meaningful schema. Cognitive style is an aspect of overall personality and cognitive processes.

Others postulate that cognitive style is a bridge between cognition/intelligence measures and personality measures [113,114]. Learning style is also sometimes synonymous with cognitive style [115, 116] while others disagree stating that learning style is a preferred strategy, thereby implying that a person's learning style can change, while cognitive style is an immutable characteristic of personality [114, 117].

Ausburn [103] defined cognitive style as the "…psychological dimensions that represent the consistencies in an individual's manner of acquiring and processing information (p. 338)" [103]. In the same perspective Messick [95] added that cognitive style deals with the manner in which people prefer to make sense out of their world by collecting, analyzing, evaluating, and interpreting data. These styles are thought to remain consistent preferences throughout life [104].

Based on Ridding and Cheema [114] there are a variety of cognitive style measures, as well as many different names for the same personality dimension [117]. This study will focus on the cognitive construct style approach refer to as Field Dependence – Independence. The other cognitive construct styles that exist in the subject matter but will not be investigated are:

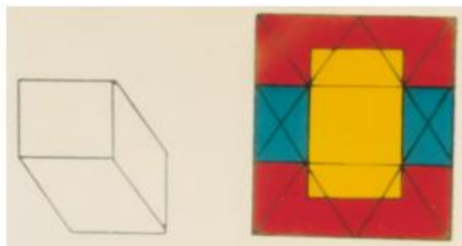
1. Reflection -Impulsivity,
2. Field Holist – Serialist,
3. Deep-level/Surface-level processing.

2.2.1 Field Dependence – Independence

One of the most researched cognitive styles to date, is the measure of field dependences [118] which was initially introduced by Witkin in the 1950's and 1960's.

The original tests were done using the Body Adjustment Test and the Rod and Frame Test. In these tests subjects were asked to determine their alignment/misalignment with true vertical given internal and external stimuli that may differ [90].

In the Body Adjustment test subjects were asked to determine the position of their body in the space. From the results it was found that "*one group of subjects determined their alignment as vertical based exclusively on the visual cues in the room. These subjects were field dependent that is they were unable to determine their vertical alignment because of a discordant visual field while other subjects displayed field independence and were able to perceive their alignment as separate from the visual* *surroundings*”[90].In the same way, the Embedded-Figures Test determines a subject’s field dependence/independence based on the time they take to find a simple figure in a more complex visual field [90]



Embedded Figures Task. Is the simple shape (on the left) hidden inside the colorful, complex figure?

Figure 1: Embedded Figure Task – By Elizabeth Leigh Walter (VISUOSPATIAL CONTEXTUAL PROCESSING: ILLUSIONS, HIDDEN FIGURES AND AUTISTIC TRAITS, 2007)

The results of the Embedded-Figures Test as presented by Witkins [118] show that subjects who were field dependent spent more time finding the figure while field independent subjects found the figure quickly. Moreover, Witkins [118] comments on education that field dependent students prefer to work in groups, and require more motivation and more structured reinforcement from teachers. On the other hand, field independent students prefer individual work and tend to be intrinsically motivated.

2.2.2 Hidden Figure Test

The study having consider all the possibilities, had chosen to use the Hidden Figure Test (HFT) for determining the users’ level of field independence instead of the Embedded Figure Test. The HFT introduced in 1976 (Ekstrom, French, Harman and Dermen,) and it asked participants to determine which of five simple lined shapes is “hidden” inside a complex figure, composed of many intersecting dark lines on a light background. Exactly as it is shown in the next figure:

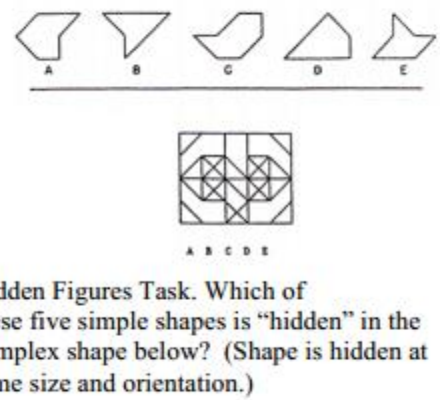


Figure 2: Hidden Figure Task – By Elizabeth Leigh Walter (VISUOSPATIAL CONTEXTUAL PROCESSING: ILLUSIONS, HIDDEN FIGURES AND AUTISTIC TRAITS, 2007)

The observer must indicate which of the five simple shapes comprises a subset of the lines in each complex figure. Beyond simply searching for a particular simple shape within a complex figure, this version of the task necessarily involves extensive executive control processes needed to keep in mind which simple shapes have already been searched for, so as to rule out four of them as candidates. From the HFT participants that are field independent tend to suppress unnecessary lines in the HFT to zero on the hidden shape, as well as to ignore the misleading, tilted frame in the rod-in-frame task.

In general, individuals are classified as Field Dependent (FD) and other individuals are categorized as Field Independent (FI) based on their reliance on the context. The case of having people fall in the middle of the range are determined as Field-Mixed (FM) or Field-Neutral.

The main difference between FD and FI learners lies in visual perceptiveness [94]. For instance, FD learners, if asked to identify simple geometric figure [97, 161] that is embedded in a complex figure will take longer to detect the simple figure than FI learners, or they may not be able to find it at all. A study by Nisiforou et al (2013) found a large variation in task completion time among the FD-I cognitive groups [160]. These difficulties of FD learners are mostly shown when separating incoming information from its contextual surroundings, FD learners are more likely to be influenced by external cues and to be non-selective in their information uptake. On the other hand, FI learners face difficulty in abstracting relevant information from visual instructional materials, especially when it comes to internal cues [90, 98, 99, 100]. It is important to note that the differences between the two cognitive styles in relation to web search tasks has already been studied in previous studies [90, 101 ,160,161] and it has been proofed that differences exists.

Moreover, based on the behavioral science studies figures have shown that FI people appear to be cold and detached; thus, they are socially isolated but have good analytic skills, whereas FD individuals are strongly interested in people and get closer to the person with whom they interact [102] .

Although field dependence – independence had received a lot of research interest at the past they have been some detractors. Among them McKenna states that field dependence is not a cognitive style at all but a measure of ability or intelligence. From his tests it was found that there is significant correlation between scores on the Embedded Figures Test and standard intelligence test scores (1983).

2.3 FD -I Dimensions

During the years many academics had involved in the exploration of cognitive dimensions. Some of the most important studies that have revealed interesting aspects related to cognitive styles (perceptual style) are presented in this section.

Daniels [105] in 1996 had summarized the general tendencies of field dependent and independent learners as follows:

Field-dependents:

- Rely on the surrounding perceptual field.
- Have difficulty attending to, extracting, and using non salient cues.
- Have difficulty providing structure to ambiguous information.
- Have difficulty restructuring new information and forging links with prior knowledge.
- Have difficulty retrieving information from long-term memory.

Conversely, field-independents:

- Perceive objects as separate from the field.
- Can dissembled relevant items from non-relevant items within the field.
- Provide structure when it is not inherent in the presented information.
- Reorganize information to provide a context for prior knowledge.
- Tend to be more efficient at retrieving items from memory (p. 38)

In the following table are shown the differences between FD/FI user's characteristics:

Field dependent (FD)	Field independent (FI)
Externally directed, easily influenced by salient cues in the interface	Internally directed, process information with own structure
Focus on global experience and struggle with individual elements	Focus on analytical experience, good at taking individuals element out of context
More likely to accept ideas as presented to them	More likely to accept ideas through strengthened analysis
Respond better in a group	Prefer to learn more individually
Humanities science	Basic science
Interpersonal skills	Analytic skills

Table 1: Comparison between field dependent and Field independent. Source: Witkin et al (1977), Ridings & Cherma (1991), Ahmadzade & Shojae (2011), Saracho (2003)

In another study [109] it has been investigated the effect of cognitive style on achievement with 179 students who enrolled in an introductory education course at two universities in the United States. The results showed that: Field independent learners seem to be superior in contrast to field dependent learners on tests measuring different educational objectives.

Therefore the researchers had concluded that cognitive style had a significant association with students' academic achievement. Similar to the above study had been performed by Tinajero and Paramo [110]. The researchers for this study investigated the relationship between cognitive styles and student achievement in several subject domains (English, mathematics, natural science, social science, Spanish, and Galician). Having big sample of 408 middle school students, the researchers asserted with validity that cognitive style was a significant source of variation in overall performance of students.

The results showed that: Field independent subjects outperformed their field dependent counterparts.

In the same field [111] other researchers tried to determine the relationship between academic achievement and cognitive style of 63 undergraduate Canadian students in information management program. The results showed that: Field independent students performed better than field dependent subjects only on one of the technical courses. In other courses the two groups performed similarly. More academic achievements regarding FD and FI users can be found in Chapter 2.3.

Although considerable research has been conducted on the impact of field dependence/ independence and academic achievement they are still limited efforts to determine the relationship between web complexity and cognitive style when it comes to learning through educational websites. As it has been pointed from previous studies [106,107] cognitive style and learning can create learning strategies including the ability of learning through social environments [108] such as websites.

The study will use a paper – pencil based questionnaire for identifying subjects FDI dimension. This process can be time consuming and it can be hypothesized at this point that future studies can explore the potential of improving the measurement methods of user's cognitive load. Additionally, it can be speculated the significance of this research which targets educational environments, to be of great value, firstly because it explores a field that had not received a lot of focus from previous studies and secondly because by identifying the cognitive load of users in educational environments and providing layout options will eventually add value in the learners effort. The identification of user cognitive abilities would be performed based on the field dependent / independent classification and users' visual perception using an online questionnaire.

2.4 Visual attention

Visual attention is a field that has received a lot of focus from different point of views. In psychology there are evidences that suggest “that the visual scene is analyzed at an early stage by specialized populations of receptors that respond selectively to such properties as orientation, color, spatial frequency, movement, and map these properties in different areas of the brain” [3]. Moving a step ahead and based on the above statement this study claims that by monitoring either the eye movement or the mouse movements the study will be able to identify which structural elements, shapes, or colors mostly trigger the cognitive abilities.

Our statement is being supported by the recent study of Kanwisher and Wojciulik [4] which claims that “we are not passive recipients of the information that impinges on our retinae, but active participants in our own perceptual processes”. Moreover, Kanwisher and Wojciulik claimed that our visual attention tends to focus “on the most relevant aspect of a visual scene, relegating others to the shadows of awareness”. The previous conclusion was demonstrated by simple examples. For instance, “a basketball player looks direct his gaze to his teammate with the ball, while at the same time monitoring the movements of three other players”. This theory is known as spatial attention since attention is directed selectively to a location. Obviously though, attention can be attracted by external information that pops out of the scene, for the previous examples the referee can be consider an external information.

Pashler [50] refers to attention as the processing or selection of information at the expense of other information (visual spatial attention). Cherry and Mangun [51, 52] suggest that attention appears in early perceptual stages of processing a scene, statement which is in opposite with the claims of Osman and Moore [53] that claim that attention appeals beyond the early perceptional stage.

2.4.1 Visual attention and Visual perception

As it's been stated and above one of the goals of this study is to provide a framework that will be used as a base of methodologies and techniques for developing less complex webpages for the different cognitive styles. To full fit the task it is needed to identify which elements attract visual attention and which of them stay in the blind side. The greater the visual attention the higher are the performance scores towards searching a target item within a website [10, 11, 12, and 13]. Experiments already made [10, 11, 12, and 13] let participants searched within three-dimensional arrays for a target item that was distinct by a conjunction of stimulus features (ex., a red X among red O's and black X's). Typically, the search time increased with the number of items in the display [14]. This finding promotes the fact that as the elements in a webpage (complexity) increases the time needed for finding an item extends. On the other hand search performance improved when the participants limited their searches to items that possessed one of the two defining stimulus features (ex., red). Therefore, it can be claimed by the above research that a website having several elements of different shapes and colors can be a factor of complexity. The complexity has been given through the years various definitions. One of the easiest to remember theories is the one of Lloyd [15], who proposed a classification of three categories: how hard is to describe, how hard is to create and what the degree of organization it has.

Beyond that in the field of complexity we can spot many theories trying to define and measure complexity; to name few: fractal theory [16], fuzzy theory [17] and more frequently found, information theory [18] and cognitive load [120]. For the purposes set in this research we will investigate some of the theories around visual attention in order to be in a position to understand how visual attention works. Previous studies provided two types of attentional selection, spatial locations (space-based attention) or by perceptual objects (object-based attention). In the next two chapters would be shown those two types of attentional selection along with other types of attentional selection.

2.4.2 Space – Based Attention

For the space-based attention theories, the visual attention picks continuous locations in the environment (stimulus). Such a theory is the "filter theory" [16] which hypothesizes that selection is being applied based on filter out of non-selected information due to the limited perceptual resources of the individual; the "spotlight" theory [19] supports that attention works like a spotlight which illuminates the focused location while moving one location to another through the operations of "disengage-move-engage"; the "zoom-lens" theory [20] proposes that attention is stealthily directed to a region of space with the varying scope of the focus; the "Feature Integration Theory" (FIT) [14] implies that attention aids to bind several properties of an object properly.

2.4.3 Object Based Attention

In contrast to the spaced based attention theories, object based attention theories facilitate selection of whole perceptual objects [21] or group of objects rather than always selecting a continuous region of space [22]. In the object based attention, the spatial location of the object is just another property of the object just like color, shape, or motion. Only in cases where feature detection is evaluated the location of an object may have higher ranking than the other properties. In the case where in a spatial location do not exists any objects that area is not considered in the selection. In summary, the main difference between the object based attention theories and the spaced based attention theories is in the nature of attentional selection. The object based attention has been researched mainly by psychophysics (e.g. 23, 24) and neuroscience (25, 26).

2.4.4 Top-down / bottom-up mechanism

They are two types of attention which are commonly distinguished in the literature: bottom-up and top-down attention, or *stimulus-driven* and *goal-oriented* attention [121, 122, 25, 123].Top-down attention refers to the voluntary allocation of attention to certain features, objects, or regions in space. During this process the brain directs the eye to focus on one or more objects in a scene that are relevant to an observer's given goal [124], such as a small region of space in the upper-left corner or to all red items. Bottom-up attention is not voluntarily directed attention. Salient stimuli can attract attention, even though the subject had no intentions to attend to these stimuli [128,129,130]

For instance, if two persons are engaged in a conversation, but a loud bang occurs, this bang may attract attention of the subjects. Another case is where someone looks for red items, but an unexpected, sudden appearance of a non-red object may unintentionally draw the attention of the subject. Even though the subjects does not have task goal in mind their attention had been in both case distracted and focused on another point. Top-down attention is also referred to as endogenous or sustained attention, and bottom-up attention is commonly typified as exogenous or transient attention. Furthermore, top-down attention seems to take longer to deploy than bottom-up attention, approximately 300 and 100–120 ms, respectively [131]

2.4.5 Cognitive Load

Cognitive load theory has been introduced in mid-1980s by John Sweller [145]. The key aspect of this theory is the relation between long-term memory and working memory, and how load on cognitive system affects learning. According to the cognitive load theory, during the process of learning, a cognitive load is imposed on the working memory. For learning to be efficient, the amount of cognitive load imposed must not exceed the capacity available in working memory. Cognitive load theory suggests three types of cognitive load [145]:

Cognitive load types	
Germane cognitive load	This type of cognitive load is caused by the learners own **active effort to construct new schemata**. ”*Effective instructional methods encourage learners to invest free processing resources to schema construction and automation, evoking germane cognitive load.*”[146]
Extraneous cognitive load	This type of cognitive load is caused by **inappropriate instructional designs** that do not take into considerations mentioned limitations and architecture of human memory. Sweller and other researchers have proposed various methods for improving instructional design. Since most of them is oriented on learning from multimedia materials, they are listed and explained in the Cognitive theory of multimedia learning section.
Intrinsic cognitive load	This type of cognitive load is caused by **element interactivity** or inherent complexity of the information which needs to be processed. For example, when translating a number of words intrinsic cognitive load is quite small, but when translating same number of words forming part of a sentence intrinsic cognitive load is higher since not only meanings of individual words, but also their relations must be analyzed. Newly suggested techniques to reduce intrinsic load include simple to complex ordering or molar instead of modular presentations.

Table 2: Cognitive Load Types,
Source: http://teorije-ucenja.zesoi.fer.hr/doku.php?id=learning_theories:cognitive_load_theory

The reduction of extraneous cognitive load may allow an increase in germane cognitive load. Also, if intrinsic cognitive load is rather low (information to learn is not complicated), it can be learned even though extraneous cognitive load is rather high (learning material is badly designed).

2.4.6 Characteristics of visual attention

Below some of the main characteristics of visual attention are found as those have been investigated and analyzed by various researches. Those characteristics are considered important for the nature of this research because they provide previous knowledge regarding how visual attention is driven and whether during that eye movement we will suffer from time cost.

By the term “control of attention” we concern about how visual attention is deployed or driven by the properties of objects and by the objects themselves. William James [27] was the one who introduced the concept of two major distinctions about the control attention, whether it is goal-driven, controlled in a top-down fashion in which the attention is the result of deliberate act or intention of attentional readiness; and on the other hand the other prospective of stimuli driven attention controlled in bottom-up fashion in which attention is captured by some salient attributes of objects that are not necessarily relevant to perceptual goals. Yantis [28] research had the same results; he too concluded that attention can be directed to locations in space “by a conscious and voluntary effort” but it can be also be captured by unexpected stimulus events. In either case both researchers have suggested in one way or another that bottom-up and top-down mechanisms complement one another. More importantly, they concluded that the deployment of attention in a scene is determined by an interaction between the properties of the scene and the observer’s set of attentional goals [34].

2.5 Visual Memory

The second important cognitive ability that we will investigate in this study is the visual memory of the viewer. Visual memory is one of several cognitive systems, which are all interconnected parts that combine to form the human memory [31].

Visual memory as it has been described by Tulving [32] is the “neurocognitive capacity to encode, store, and retrieve information”, Tulving also mentioned that there is a possibility that more than one memory systems exist. BerryHill [33] who has the same perspective as Tulving added to the above theory the extend that memory occurs over a broad time range spanning from eye movements to years in order to visually navigate to a previously visited location. Based on BerryHill, humans are able to place in memory visual information which resembles objects, places, animals or people in a mental image. The experience of visual memory is also referred to as the mind's eye through which we can retrieve from our memory a mental image of original objects, places, animals or people.

Future studies [34], tried to identify and taxonomy the memory systems as those had been described by Tulving; based on their characteristics of timing, conscious access, active maintenance, storage capacity, and mechanisms of operation.

One of the first researchers on the subject was William James [27] who had proposed to categorize memory as primary (the information held in the “conscious present”) and secondary memory which consists of information that is acquired, stored outside of conscious awareness, and then later remembered. In the same philosophy [35, 36, 37] modern authors separate memory into short-term memory (working memory) and long-term memory with the only difference between them relying in the capacity (how much information they can store). The active memory which is the working memory of the brain is limited to few items [38, 39, and 40] in comparison with passive memory which can store thousands of items [41, 42, and 43). From every day scenes and events [42] to shapes of arbitrary forms [44].It’s not that we remember the essence of the picture, but we are able to recognize which precise image we saw and some of its details [44]. Additionally our brain works in selective mode it has the ability to recognize which pictures are important and which are not. Usually we remember pictures that involve friends, fun or special events like a trip [40, 42, 45, and 46].

2.5.1 Memorability of a scene

Although it seems obvious that some images will capture our attention and it will be less difficult for us to remember them, yet it have not been addressed probably in previous experiments. Does the images have the same effect on everyone? Which factors can make a person remember a scene? How do we process the information if it is wrap in texture or other symbols just like a website does? In order to answer the above questions the study would collect websites of educational content, each of them having different structure, colors and more generally being different the one to another. Then participants will be asked to rate each educational website through an online questionnaire so that that the study collects data regarding the complexity of the website.

2.5.2 Visual Memory and Visual Attention

The information received by an individual at the moment of viewing a scene they exists in the short-term memory (working memory) [35, 36, 37], the so called active memory. In fact, it been believed that the contents of the working memory and attention often overlap, even though we do not have yet a clear relationship between the two, previous studies have tried to investigate characteristics of this relationship.

Theorists claim that visual attention picks the information to be encoded and stores it temporarily into the working memory, although others define attention in term of post-perceptual processing limitations [59, 60]. Additionally it's been claimed that the two cognitive abilities share a uniform set of process. In contrast [56, 61], Posner provides documented comparison and claims that the two systems are non-unitary. Awh [62] suggested that the communication of attention and working memory heavily rest on what stage attention is been engaged and what type of information is being maintained in working memory. Baddeley and Logie [63] have suggested that they are independent stores for verbal, spatial, and visual information while evidence exists that the processes involved in the storage of items in working memory are separable from the processes that manipulate or update the contents of working memory [68, 67, 66, 65, 64,61].

2.6 Tracking devices

Eye tracking is a technique that can be used by a researcher to monitor where a person is looking at any given time and the sequence in which their eyes are shifting from one location to another. This technique is frequently used by HCI researchers who try to understand who visual information is being processed and what are the factors that might impact upon the usability of system interfaces. Thus, eye tracking data can provide an objective source for analysis and improvement of the interface (In the Appendix can be found a series of research made for eye-tracking (Table 1)).

In this research due to the time constraints instead of using eye tracking devices which need more time for collecting and analyzing data, pointing devices would be used to capture the mouse clicks of the user on the graphical user interface (See Appendix – Table 1) and the time needed for the participants to complete the task. Because of the chosen technology the research excludes certain groups of the population such disabled individuals that may not be able to use such a technology.

Regarding previous HCI studies with the use of eye tracking they can be found examples from the 80's. In those days the emerging technology seemed particularly handy for answering questions about how users search for commands in computer menus (see, for example, Card [150], Hendrickson [153], Altonen et al [151] and Byrne et al. [152]). The 1980s also helped in the start of eye tracking in real time as a means of human–computer interaction. Early work in this area initially focused primarily on disabled users (ex. Levine [154], Levine [155]). In more recent times eye tracking in human–computer interaction has shown growing both as a means of studying the usability of computer interfaces and as a means of interacting with the computer. In the 90's researchers turned to eye tracking to answer questions about usability (ex., Benel et al [156], Ellis et al., [157]; Cowen [158]) and to serve as a computer input device (ex., Starker and Bolt, [159]). Just and Carpenter [69] claimed that the image which a person is looking can be a strong indication of the thought “on top of the stack” of cognitive processes. At this point, it can be alleged that what user sees is what the user will try to inspect, therefore it can be forecast that the elements that an individual is been attracted to would be the ones that the individual will click on with the mouse. Based on that hypothesis the tracking data of the mouse clicks can provide a dynamic trace of where an individual attention is being directed in relation to a visual display. Additionally mouse tracking data can be used to provide many meaningful indications, for instance it can be understood the process is being applied to an object by judging the fixations of the mouse on a certain object. The process used in real life for obtaining those meaningful indications requires the researcher to define “areas of interest” (AOI) over certain parts of a display [70]. Based on Michailidou [71] the most common AOI among the pages are header, menu, footer and main content. In the past they have been studies [72, 73] who investigated AOI for positioning navigation menu in a website, the results showed the upper left corner.

2.6.1 Tracking movement – Conclusion

For our study the mouse tracking movement it is been consider as mandatory for reaching valid data. The data is an important and objective technique that provides useful advantages for the in-depth analysis of web interface. Currently most of the HCI studies rely on tracking data (mostly eye tracking technologies), thus it becomes an established addition as a usability testing methodology not only for HCI academics but also in commercial studies or products. Due to the increase demand for HCI studies during the last decade we have witness the decrease in cost for technologies such as eye tracking.

2.7 Webpage Structure

A web page can be consider as a set of elements which when put together they build a complex visual image, rendered and displayed by a browser (browser: special software for viewing web pages). Consider in this case the term “image” not as scenic photo, but more like a complex scene previewed in the browser. We consider it complex because it’s a mix of text, graphic elements, links, formatting, and other aspects which sometimes can be quite difficult for the user to browse.

The development of website often follows common patterns which been established through the years as design guidelines for creating a Web page Layout [81]. These Websites often contain certain elements at specific locations (e.g., logo, navigation bar, banners). Thus, the users developed certain expectations about where each item is located inside a Webpage [82]. However this does not mean that because users have created certain expectations that the current layouts are the finest in terms of usability. Our role is to evaluate and analyze the webpage’s in terms of their complexity so that enable the distinction between the usable layouts and the non-usable.

Webpages are separated to dynamic or static, static web page is a web page that is delivered to the user exactly as stored, in contrast to dynamic web pages which are generated by a web application. In both cases for the content to be displayed, it is needed to be embedded into webpage HTML code. HTML or Hyper Textual Markup Language is the main markup language used for displaying information to the browser. The HTML consist of elements which are described in pair of tags i.e. <p>Hello</p>, every pair of tags has its own functionality. In the example it is shown the tag “p” which will simply display in a webpage the content inside of the tag as plain text.

When an individual types in the browser URL a specific web address, at that moment a request is been made to a web server for sending the stored webpage it has. When the browser receives the HTML data, it transforms it internally into a formal representation, the document object model (DOM). In the DOM exists all the different element the author of the website has placed (i.e. inks, images, text paragraphs, etc.) for the viewer to see. In the past Ivory and Hearst [83], tried to predict abstract web page characteristics based on the general design they had created measures based on the DOM that could be used to automatically predict the overall Web page quality (quality in this case represents usability and aesthetics).

In general it has been suggested by Germonprez and Zigurs [132] that website visual perception is affected by cognition, content and form. Human cognition has an effect on how users retrieve and use information in a website. Content on the Website and the amount of information that is available affects complexity since it can cause information overload on a page. The form of the Website with respect to user interface, navigation, and structure is a further factor that affects page complexity.

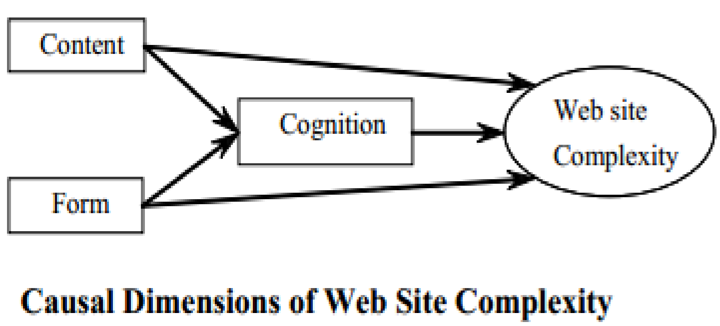


Figure 3: Causal Dimensions of Web Site Complexity –Source: Causal Factors for Web Site Complexity, Matt Germonprez and Ilze Zigurs [83]

The HTML DOM is the framework at which the content and the form of a website is being placed and displayed, therefore for evaluating the visual perception of an individual the study needs to analyze the HTML DOM structure.

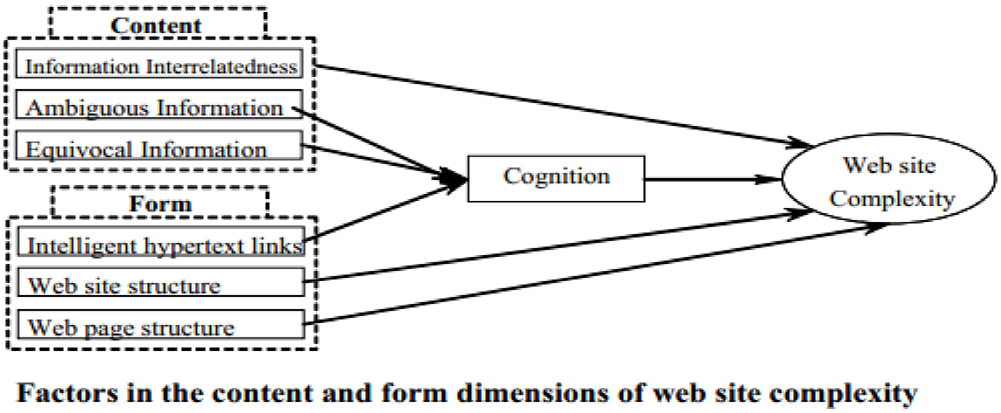


Figure 4: Causal Dimensions of Web Site Complexity –Source: Causal Factors for Web Site Complexity, Matt Germonprez and Ilze Zigurs [83]

For analyzing the HTML DOM structure the ViCRAM algorithm will be used (it will be detailed explained in another section of this study) which can calculate give strong indications relating to the complexity of a webpage based on the HTML DOM, ex. Count the number of images within a webpage, count the number of nested elements and other important information.

2.7.1 Visual Complexity and HTML DOM structure

Previous studies that used ViCRAM algorithm have produced valuable output regarding HTML DOM structure and web perception of a webpage. Such a study has been made by Michailidou, Harper and Bechhofer [133] who have tried to correlate structural elements, visual complexity and aesthetic scores taken by questionnaire, the results are shown below:

From the above table it can be seen that different structural elements create different perception for the user, ex. The menus compared to texture have much more complexity for the user; the same phenomenon exists between images and links.

Michailidou [71] concluded that there is a high correlation between the layouts of Web pages and their web perception. Hence, one of the goals of the study is to develop a structural analysis for extracting the layout. From the obtained layout would be extracted the layout features aiding in the extraction of visual features. According to Ahmad [134] who defines layout in design research, the layout of a page is a set of unoverlapped large rectangular blocks that (approximately) cover the whole page. These rectangular blocks are also called layout blocks. Below are shown three examples of different layouts:

Figure 5: Different website structures.

For being able to extract the structural elements from a website the study must be able to segment the webpages into blocks and extract information from the blocks. They are numerous well known webpage segmentation algorithms as those have being proposed in previous literature [135, 136].

Cai [135] introduced the visual-based page segment (VIPS) algorithm to determine the structure of a Web page. VIPS algorithm is based on many web appearance cues, such as split lines, decorative images, colors and fonts. Visual appearance cues are utilized to distinguish the different parts of a Website and find useful content blocks within the webpage. Wu [137] proposed an automatic approach for determining whether a page is aesthetic. Thus focuses on discovering useful information (ex. content blocks) based on Web appearance. Another approach for measuring the complexity of webpage that can work in correlation with structural analysis of the DOM, is by investigating the area of images [139, 140], electronic displays [141], and 3D graphics [142]. Rosenholtz [140] proposed two methods for image visual complexity measurement:

a. Subband Entropy (SE)
b. Feature Congestion (FC)

Subband Entropy is based on the perception that Complexity is related to the number of bits required for subband (wavelet) image coding. Subsequently, a larger number of required bits results in greater Visual Complexity.

Feature Congestion on the other hand, is seen as the difficulty measurement of adding a new salient item to an image. A higher difficulty value indicates a higher Visual Complexity.

Other approaches for image visual complexity measurement

With a different perspective Sickel [143] introduce a different approach for measuring image visual complexity. Using the sizes of digital images after compression (e.g., jpeg and zip), Sickel suggests that a larger file size indicates higher complexity [143].

Gero and Kazakov [142] investigated the Visual Complexity of 3D graphics. The geometry of 3D graphics can be represented by a graph, and the complexity of the graph is then calculated based on the probability distribution of different node types in the graph.

2.7.2 ViCRAM

Michailidou [71] introduced an extraction algorithm that utilize three features, namely, top left corner counts (TLC), word counts (W), and image counts (I) to construct a linear model expressing Visual Complexity = 1.743 + 0.097TLC + 0.053W + 0.003I, where TLC represents the number of distinct sections a Web page is organized into. For counting top left corner counts (TLC), word counts (W), and image counts on a Web page the following steps are made [144]:

1. TLC counts with the following manner:
    a. Chunk rendering of the page is created based on cues, such as background colors, headings, stand-alone images, and visual lines or borders;
    b. The page is divided into boxes, each of which contains a section or subsection; and
    c. The top left corner of a box is counted provided that its left and top sides are not adjacent or have a common side with another box.
2. Word counts comprise all texts used to present any type of information on the page, including texts from menu lists and within images.
3. Image counts contain any image on the page such as advertisements, logos, and decorative images.

From these three features are described several key factors related to the visual presentation of a Web page, such as color, layout, texts, and images.

ViCRAM Summary

This research needs to identify the web complexity of the webpages been investigated, for doing so it needs a mechanism that will help extract information from the structural elements of the webpage. The ViCRAM algorithms have been chosen for this task. The reasons that navigate this research in selecting the ViCRAM algorithm are:

1. Can be easily modified for added functionality.
2. Can produce valuable outcome based on previous studies.
3. Sufficient literature on ViCRAM algorithm.
4. No need for strong hardware support

2.8 MOOC's

From the introductory section of the study it has been referenced that this research will focus on educational environments. For the purposes of the study, have been chosen websites known as Massive Open Online Courses (MOOC's). Massive Open Online Courses (MOOCs) is a term used for describing the web technologies that have enabled educators to create virtual classrooms of thousands of students. The typical structure of a MOOC consists of 10-20 minute lectures with built-in quizzes, weekly auto-graded assignments, and professors moderating the discussion forums. MOOC's are different from Universities distance learning degrees since they do not always lead to a former qualifications and they do not have entry qualifications. On the other hand they are offered by prestige Universities like Harvard or Yale for free, and they attract a large number of learners which turns them to good sample for our research.

[1] http://www.coursera.org
[2] http://bostinno.streetwise.co/2013/05/21/edx-partners-with-15-more-schools-including-boston-university-and-berklee/
[3] http://en.wikipedia.org wiki/Udacity
[4] http://futurelearn.com/

MOOC platform, country	Quoted student numbers (date of announcement)	Number of courses (as of 28/5/13)	Number of institutions
Coursera, US [1]	3,670,803 (on 28/5/13)	374	70
EdX, US [2]	900,000 (approx. May 2013)	53	27
Udacity, US [3]	400,000 (approx. May 2013)	25	1
FutureLearn, UK [4]	N/A	N/A	21

Table 3: The Maturing of the MOOC [148]

Chapter Three

3.1 Methodology

The perception of the visual complexity of an individual in the World Wide Web is a topic of significant interest. Individuals' cognitive characteristics and web pages visual complexity have been gaining ground in the literature. Previous studies (as those has been described in Chapter 2) had examined the relationship between complexity and various aspects of a presentation, including font styles, colors, images and overall layout of the page [134]. With this thesis the correlation of user's cognitive abilities in terms of users perceptual style (FD-I dimension), and their visual perception while browsing in the World Wide Web would be investigated. Thus a comparative evaluation of two methodologies will be used, firstly the identification of user perceptual style, and secondly the evaluation of their visual perception while interacting with websites who are having different visual complexity.

By using the above methodology the study tries to relate users' visual complexity perception with their perceptual style (FD-I dimension). By monitoring users' web behavior it can be asserted that a relation of user cognitive characteristics such as visual attention patterns can be related with visual complexity, as this would be measured and used for comparison. In order for the study to collect data regarding the users' visual perception, participants must rank MOOC's webpages based on their visual complexity and undertook a time completion task that would be used for demonstrating the differences in time completion between the different groups based on cognitive load. The main tool for tracking users' action would be a mouse tracking device that will track user actions and the time taken for completing the task.

3.1.1 Purpose

The purpose of the study is to understand the user cognitive effort required when interacting with educational web pages. It is important to mention that such a study would demonstrate a unique output because by understanding the difficulties of cognitive groups to identify an element within MOOC sites (based on time) that are having different scores in complexity. The study would be able to correlate the complexity of educational environments with the perceptual style of users for revealing:

1. The elements within a website that possibly affect the visual perception of the visitor.
2. The cognitive load differences of each cognitive group in processing the information.
3. Possible gabs in the complexity algorithm ViCRAM.
4. The relationship of cognitive groups and the visual complexity
5. A set of good practices for the website developers.
6. An evaluation of the MOOC sites (those included in the time completion task) regarding the visual perception of participants within them.

3.1.2 Objective

In any research the researcher seeks to find answers in certain question that until that moment they are unanswered by the field he is exploring. Moreover, in any study the research needs to set some research questions that would be used as the path for reaching the main objective of the study. In this study the main objective is to understand the user cognitive effort when interacting with educational web pages. Thus, the researcher questions of this study are the following:

1 Can a website visual complexity determine the cognitive effort needed for processing information?

2 Is user's cognitive ability affected by the visual complexity of the web page during navigation?

3 How does user's cognitive dimension affect user visual perception while browsing different complexity webpages?

3.1.3 Participants

The sample population in this study consisted of individuals from age 18 – 60 with the majority of them holding higher educational degrees. The participants were mostly professional in the IT industry of Cyprus, friends of the researcher, who had agreed to participate in the study. All participants were categorized for their cognitive dimension using Hidden Figure Test and all of them had normal vision. Specifically, the study had addressed individuals that if they are using vision glasses or contact lenses they could not participate in the study. The total number of participants was 20 persons. The proposed number came up after analyzing the possible margin of error that can statistically exists within the sample, based on the

Sample Size (*N*)	Margin of Error (fraction)	Margin of Error (percentage)
10	0.316	31.6
20	0.224	22.4
50	0.141	14.1
100	0.100	10.0
200	0.071	7.1
500	0.045	4.5
1000	0.032	3.2
2000	0.022	2.2
5000	0.014	1.4
10000	0.010	1.0

following table the study claims that with 22.4% of error margin, it can demonstrate valid data. Unfortunately for the study it must be performed during specific time boundaries and this is the main reason that the study haven't increase the sample population to 50 participants and consequently reduce the margin of error to the 14.1%.

Table 4: Sample Size Calculator from http://www.surveysystem.com/sscalc.htm by Niles, Robert, 2006

3.1.4 Methodologies

For this study a variety of tools and procedures would be used that are listed below in summary.

Hidden Figure Test: The hidden figure test was used in the study for categorization of participants in cognitive groups. The participants would be classified as Field Dependent (FD) and other individuals are categorized as Field Independent (FI) based on their reliance on the context. The case of having people fall in the middle of the range are determined as Field-Mixed (FM) or Field-Neutral.

Time completion task: The time completion task is a process where participants would be asked to search for an object within different educational web pages in a short amount of time. The results expected to show how the different cognitive groups respond within a limited time and under different visual complexity.

User evaluation of web page*: It is important for the study to collect quantitative metrics from the participants of the study. Therefore an online questionnaire would be used to let participants rank educational webpages (MOOC's) based on their perception. In addition the questionnaire would be used for collecting demographic and qualitative data.

Mouse Tracking Devices: The Mouse tracking device would be used for tracking the user movements within the webpages during the time completion task. The mouse movement device will also output the time needed for the participant to complete the task.

ViCram algorithm: The ViCram algorithm would be used for determining the complexity level of each website inspected for the purposes of the study. It is expected that from a population of 30 and more inspected websites, a sample of 6 would be chosen for the time completion task.

***Online Questionnaire**: Because the survey is too big to be place in a word document it can be found:

1. http://www.e-cyprus.biz/survey/index.php/633538/lang-en
2. http://www.e-cyprus.biz/survey/index.php/admin/printablesurvey/sa/index/surveyid/633538

3.1.5 Procedure

Initially the researcher collected a number of educational websites (33) known as MOOC's and run those websites against the ViCRAM Algorithm (see Appendix: ViCRAM Evaluation Data). The results produced by this evaluation had been used for classification of websites as simple, medium or complex (in regard to their visual complexity). The next step of the study was to determine the level of user field dependence – independence by asking the participants to complete a 24 minute test (32 questions) known as Hidden Figure Test (using Witkins [118] setup).

The completion of the previous step lead the users to browsed through selected educational environments (MOOC's) and perform a time completion task. The Time Completion task had asked participants to find specific information in each website. The information were preselected and a same level of difficulty was achieved. In addition, the place of each information varied across the pages to avoid any task completions due to familiarity. For each website examined the participant had been asked to find three objects. During this process participants mouse movements had been be tracked and the time needed for completing the task has been saved. The tool used for this task is named IOGraphica and can be downloaded by the respective website (www. iographica.com)

In the final task of the research participants had been asked to fill up a questionnaire; in the questionnaire participants was asked to rank websites based on their estimation for which website is more visual complex. Furthermore during this part of the study have been collected demographic data and more importantly qualitative data such as the elements which users perceive as complex.

Finally, the last step was to conduct an analysis in an effort to correlate all of the parts of the study. Additionally in this part of the study, based on the results of the analysis a lot of conclusions had been drawn regarding the research purpose and the expected results of the study.

3.1.6 Materials

From a large set of MOOC sites who have been examined (see Appendix: ViCRAM Evaluation Data) with ViCRAM algorithm a short list had been developed for participating in the Time completion Task. The educational environments selected can be found in the table 6 as shown below:

Websites Complexity Level		
P.ID*	**URL**	**Complexity Level***
6	Udacity Platform	**Simple**
21	MIT Platform	**Medium**
23	Iversity Platform	**Medium**

Find Downlables ?

24	Coursera Platform	**Medium**
27	Saylor Platform	**Hard**
29	EdX Platform	**Hard**
***P.ID:** This is the web page identification number ***Complexity Level:** The level of complexity is been derived from ViCRAM algorithm. Specifically grading below 5 is considered as Simple, around 5-8 as Medium, Above 8 Hard.		

Table 6: Selected website to participate in Time Completion Task

At this point it is important to note that the researcher had chosen to focus on the more visual complex websites consciously. The researcher had been driven to this action under the assumption that visually complex websites would delivery to the study more distance between the FD users and the FI users. Consequently it would be easier to for the study to draw conclusions during the Chapter 4 where the analysis would be made.

Another important aspect that must be noted is that the pages shown in table 6 are the ones used for time completion. Three tasks were given for each webpage. Only one webpage from each sites listed on Table 6 were examined. Moreover the user cognitive abilities in terms of FD-I dimension would be calculated with Hidden Figures Test which consists of 32 questions divided equally into two parts. The test presents five simple figures and asks learners to identify which one of those simple figures is embedded in a more complex figure. The Hidden Figures Test (HFT) would be used based on Witkins [118] setup. The Time Completion Task (see Appendix Time Completion Task) consists of three tasks for each site been examined.

Chapter Four

4.1 Participants Related Info

The questionaire part of the study was conducted online to allow participants to access it in their own time and place. From the twenty participants who had completed the questionnaire nine of them were Female gender and eleven were Males.

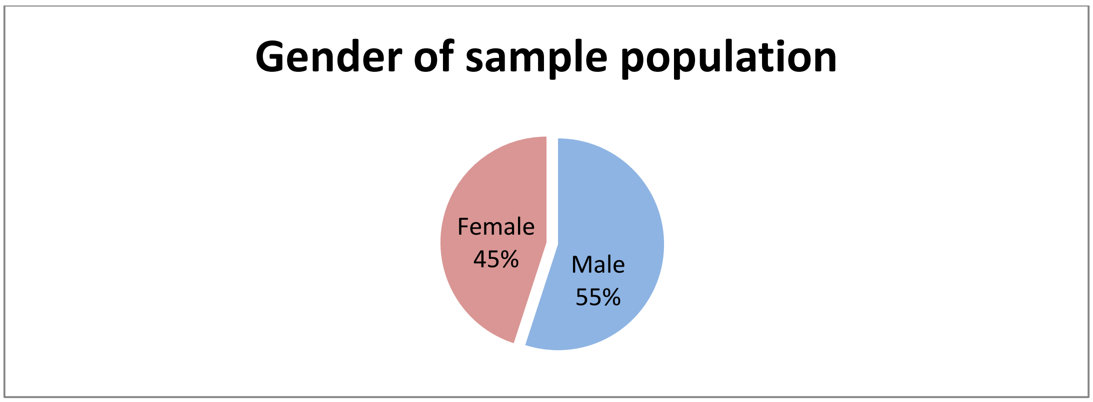


Figure 6: Gender of Sample population

The age range of the sample consists of thirteen individuals between the ages 26 -35, five individuals between 36 to 46 and one individual for each group of 46 - 56 and 56 - 66 respectively.

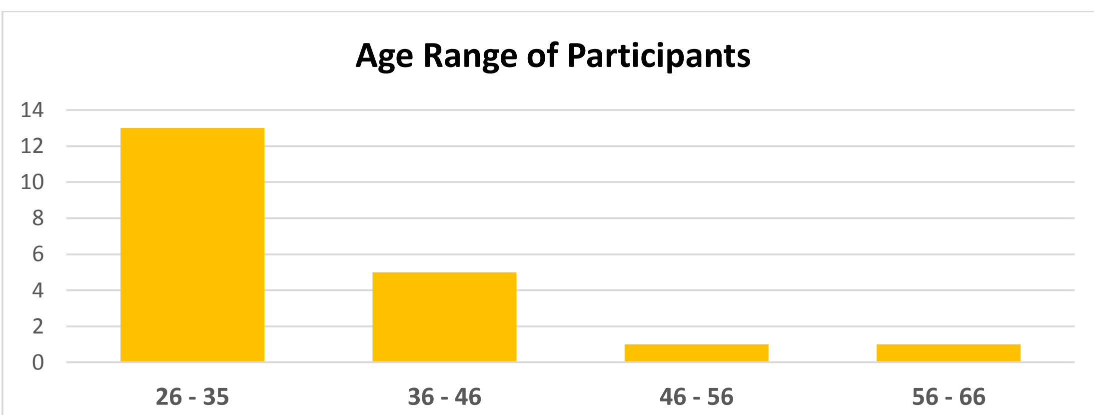


Figure 7: Age Range of Sample Population

Since all of the participants responded everyday use of the internet the only differentiation between the sample population is on the degree they actually use the computer. In the next graph is demonstrated the degree of differentiation in regard to the use of computer. From the results of the study 35% of the population answered that they use computers for more than 20 hours per week while another 15% indicates use of computer somewhere between 10- 20 hours per week. Those two figures sum up to the 50% of the total population which is a strong indication that the half population of the sample uses the computer frequently.

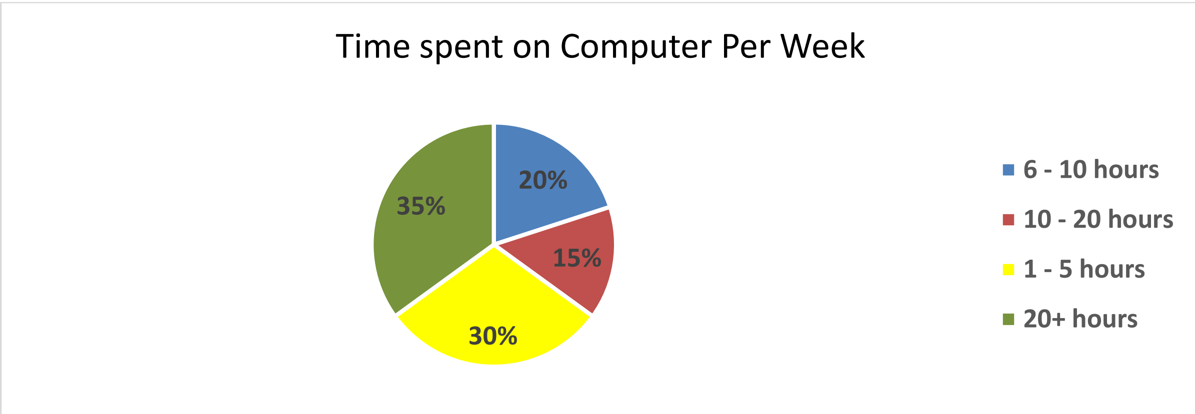


Figure 8: Time Spent on Computer Per Week

Another important finding from the results is that no one of the participants were color blind while the vast majority (except two users)were unfamiliar with the websites been investigated. This fact resembels the validity of the pages been investigated and the unbasied sample population.The next figure demonstated the education level of the sample, which can be expressed as a highly educated since 90% of the sample holds one or more Master's Degrees.

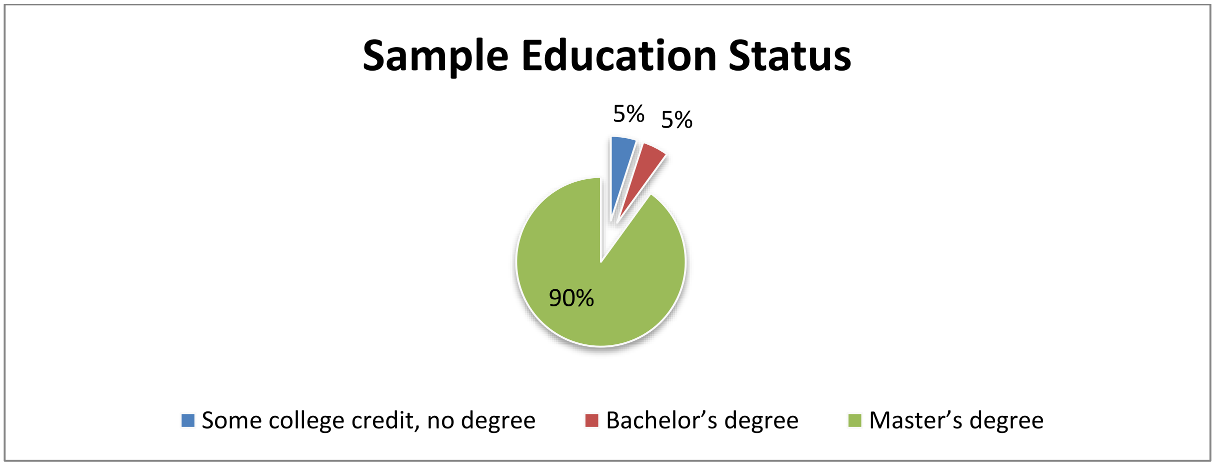


Figure 9: Education Status of Sample Population

4.2 Cognitive abilities

The score categorization for Hidden Figure Test had been developed after considering other researchers approach for setting up the cut-off scores [97,161]. Individuals who scored 10 or lower were categorized as FD, those who scored from 11 to 17 were classified as FM or FN, and those who scored from 18 to 32 as FI. Taking into consideration the classification framework, this study has 8 Field Depended participants, 8 Field Independent, and 4 as Field Mixed learners.

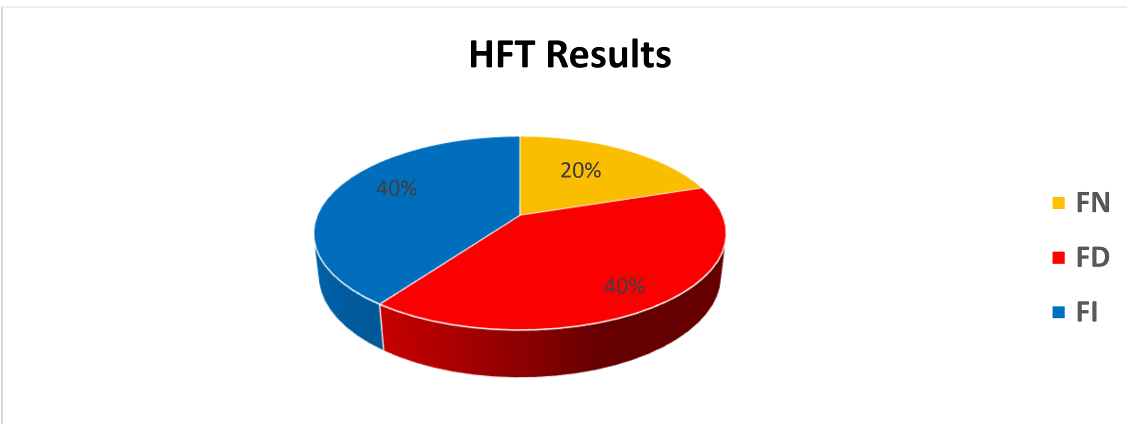


Figure 10: Hidden Figure Test Results

From the Time Completion Task results the researcher was able to identify the average time that would take for an individual within the groups to complete all of the tasks. The results are shown:

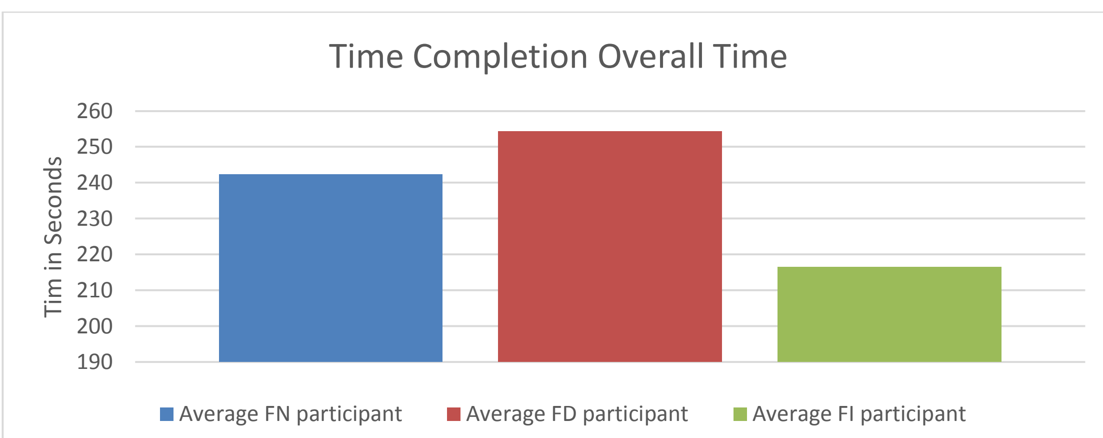


Figure 11: Average time for an individual within a cognitive group to complete all tasks.

Regarding the calculation of figure 11 the study calculated the average time as the sum of time took for all of the tasks to be completed regarding all websites divided by the number of individuals within each cognitive group. By observing the figure 11 it can be identified that an average FI user can identify objects within a website quicker than both FN and FD users. On the other hand FN users who are slower than FI users they are still faster than FD users. Therefore it can be claimed that an FD user is strongly committed to the environment in such an extent that will have difficult time find objects within complex websites.

The initial assumption of the researcher that there is a possibility for a correlation to exist between the time that it took for a user to complete all of tasks and his perceptual style it can be exposed in the following graph.

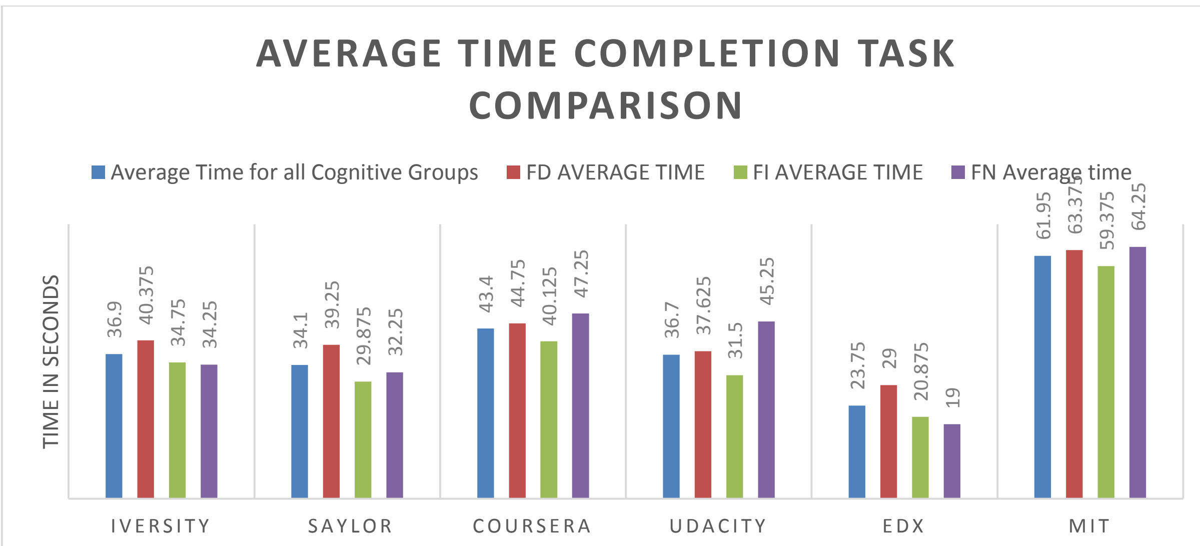


Figure 12: Average Time for users to complete all tasks. Classification based on cognitive groups

The figure 12 shows that individuals classified as FD on average spent more time in webpages trying to identify objects than other type of users. This finding is valid for half of the pages been investigated, while in the other set of pages; FD users and FN users compete very close regarding which group spends more time on identifying objects. On averagre though comparing the FD participants with the Average time for all groups (showed with blue color in graph) they have the slower time in identifying objects.

Conversely it can be reliable said that FI participants have the quickest times in Time Completion Task. This finding can be considered valid because it is true for 4 out of 6 webpages been investigated in this study. Nonetheless FI users compared with the Average time for all groups (showed with blue color in graph,figure 12) had displayed one of the quickest times . This finding clearly points that FI users can find objects quicker than other groups and regardless the level of visual complexity.

Very interesting role between the groups has been demonstrated by participants in the FN group. On average FN group relies between FI and FD in terms of time. However in some cases they had presented slower times than FD group for instance in the websites Coursera,Udacity and MIT. While on the other hand the same group had better times than FI users in educational environments such as EdX and Saylor. In an attempt to examine as close as possible each group the study choosed to analyze each cognitive group by itself. In this way the study will verified the conclusion of figure 12 but also would be able to draw more conlusions.

The first cognitive group to be analyzed is the Field Dependent (FD) group. The results for the group are showed below:

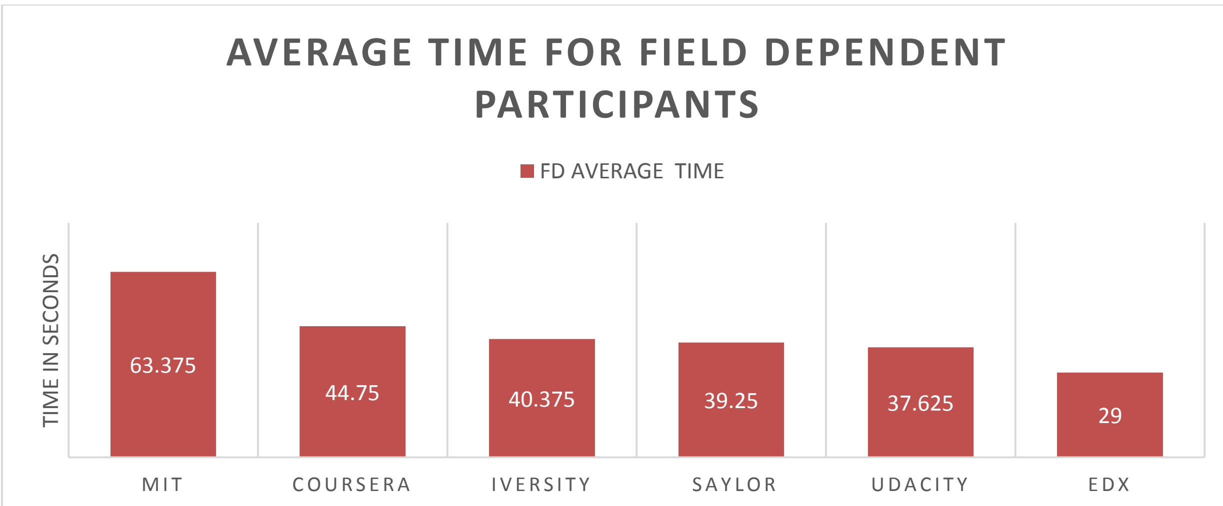


Figure 13: FD group average time for each website

By observing the graph (figure 13), it can be found that the MIT web page was more complex than the other websites. Obviously MIT website, took more time for the user of FD group to processes the specific website. On the other hand EdX website it is found to be the easiest to be visually processed by FD users since the average time for this site is less than the time it took to complete all tasks in the other websites. At this point it is important to note that all other websites (excluding MIT and Edx) had scored times around 40 seconds.The importance of this finding would be demonstrated at the next chapter where the complexity factor will join in the equation.

Next cognitive group to be analyzed is the FI group. In contrast with FD users the FI users have more ups and downs in their results. However, one of the first observations that someone can make regarding this group is that they have a common point with the FD group. The connection between the two groups is called MIT website. For both groups it can be observed that they have difficult time proccesing the context of this website. This can be happening either because MIT website is visually complex or because FD and FI group share common cognitive abilities. In regard to the second option though, it is found a little be hard that such a case exists based on the trends of figure 12. Therefore it can be assert and must be examined in the next chapter the possibility that MIT website is a visually complex website.The MIT website took around 60 seconds for all the tasks to be completed by an average FI and FD user . Below in more detail is shown the graph of an average FI user:

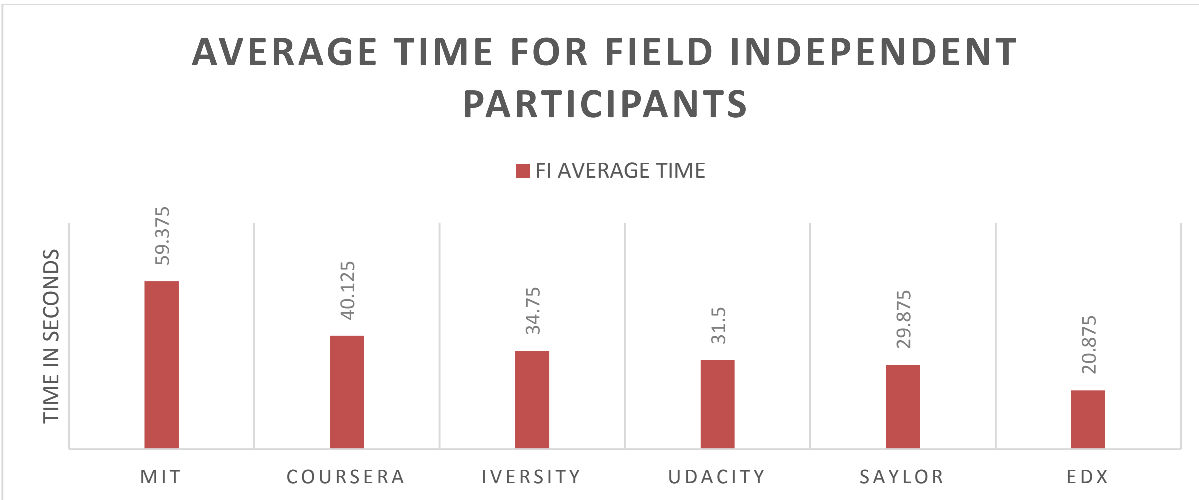


Figure 13: FI group average time for each website

Another trend that exists between FD and FI group is related to the Edx website which was found to be the less complex for both groups. In an overall, if the two graphs are been compared to each (FD-FI) other, then it can be claimed that more or less they have the similar sense in visual complexity. This claim can also represented visually by observing the respective figures in term of shape. However in regard to time FI users provided more strong cognitive abilites and therefore they have been faster than the FD users. Next graph shows the average time for an FN user :

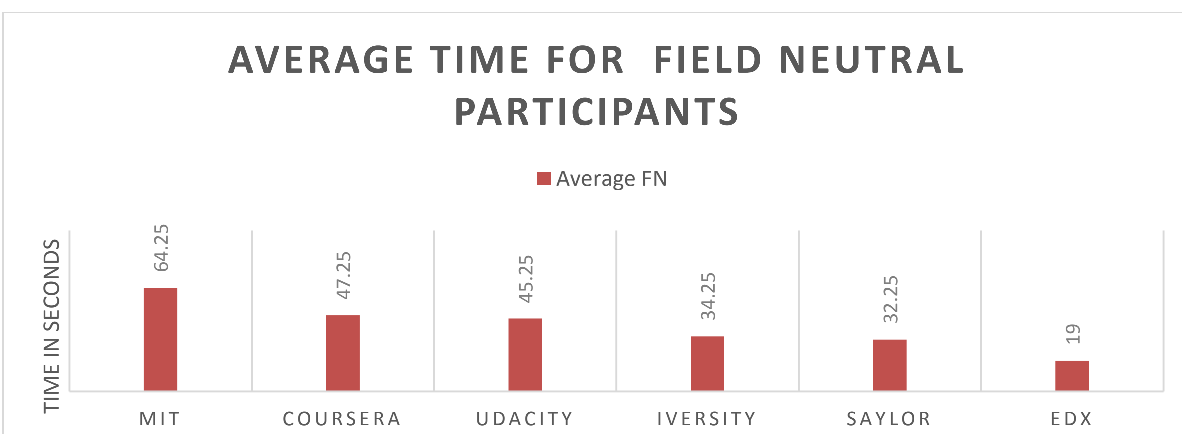


Figure 14: FN group average time for each website

The suspicision that MIT website is more visual complex than other websites and Edx is the less visual complex it is also supported by FN group. The FN group in contrast with FD and FI group had demonstrated similar sence of complexity with a slide differentiation in the website Udacity which proven to be more complex for this group to process. The difficulty for the users to perceive MIT website can be also seen in the mouse tracking data (see Appendix, Screenshots :9,10,11).

A crusial finding for the study is that FN had performed better than FI users in educational environments (websites) like Edx and Iversity. Trying to get a deeper analysis the study focused into the websites Edx, Iversity and Saylor. Those are the websites where FI and FN group had very similar performance. For those websites the study noticed that those websites are those who have been classified as the most visually complex websites based on ViCRAM algorithm. Hence it can be assert that FN group tends to get better results as the bar of complexity rises (this is an assumption based on the results of ViCRAM algorithm).

Furthermore, the study had discovered a strange finding the cognitive effort of users and their assumption regarding which cognitive group they belong. Most of the participants in the study when they asked to indicate their cognitive type group, they had different perspective regarding their own cognitive effort compared to the results of the HFT. For example a user that has been classified as FI group based on HFT he indicated himself as a user within the FN group. The graph below shows more details of this finding:

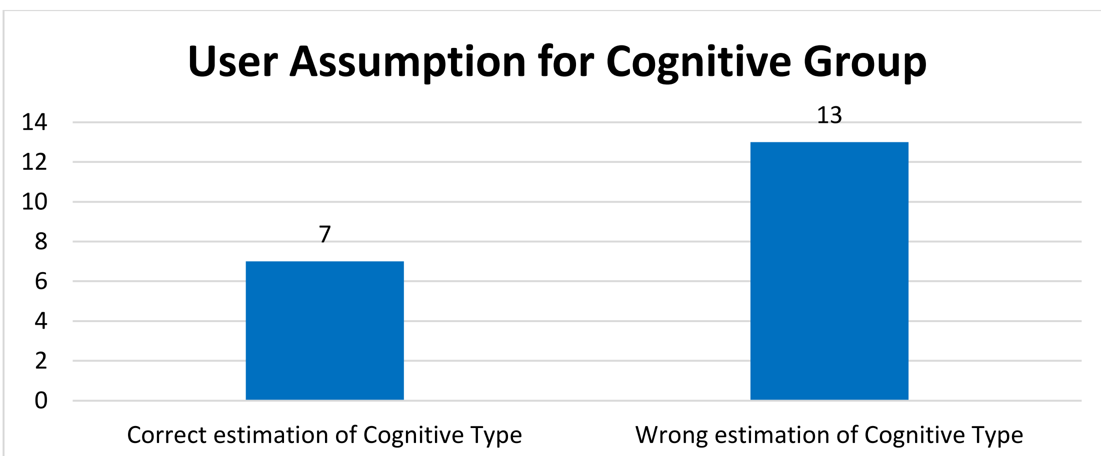


Figure 15: User assumption regarding their cognitive group

As it can be observed by the above figure the 13 participants out of the twenty had wrongly estimated their cognitive type. Remarkable is the finding that from those that had correctly indicate their cognitive type, five out of seven participants were Field Dependented.

Therefore it can be claimed that for users that belong to FD group is more easy to identify them self within the cognitive group that they belong. As a result, FD group indicates a more precise sense regarding their perseptual style.

In the next graph it is shown the standard deviation of all users within their respective cognitive groups. The results had showed that the FD group spreads its value in a bigger range than the other groups. This finding has a lot of sence, specially for the FD group, where the top portion of the population scores close to FN group and therefore they will react more or less like the FN group, while the lower end will have more field dependent behavior.

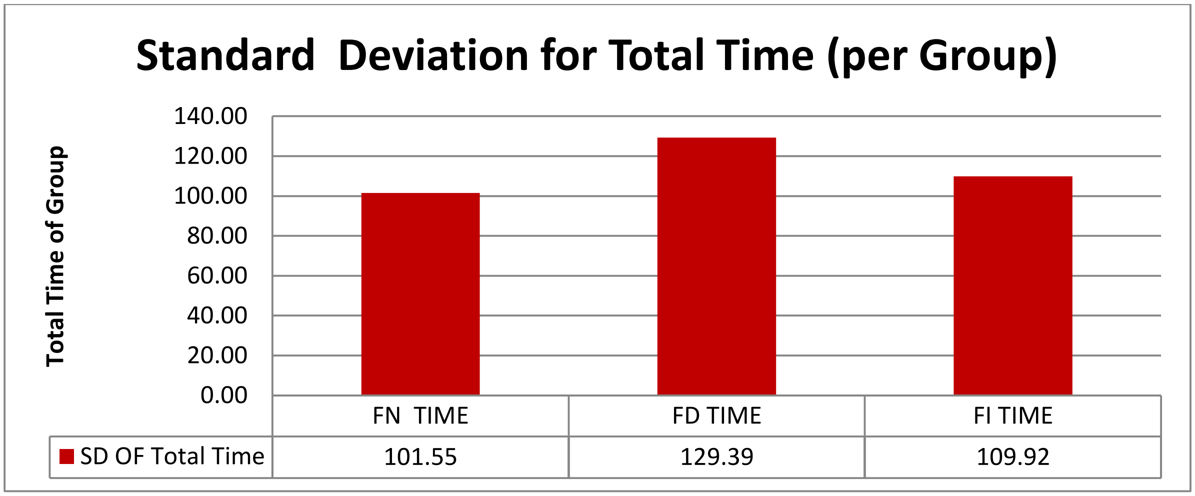


Figure 16:Standard Deviation for Total Time (per Group)

A point of convergence for all participants is that they had all agree that a user can easily find information in a visually simple Wep page. On the opposite side though, in a question asking the participants if a user can easily find information in a visually complex Web page the opinions dissociated.

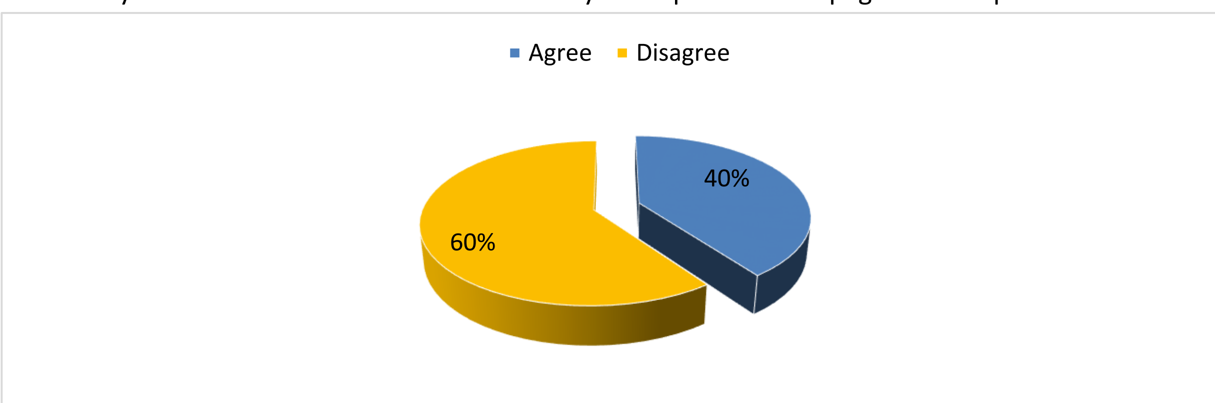


Figure 17: A user can easily find information in a visually complex Web page ?

More specifically 40% of the population agreed that a user can easily find info in a complex webpage while 60% disagrees. Because for this question it was expected to have higher results with people disagreeing an analysis of this sample was made based on the cognitive type of the users.

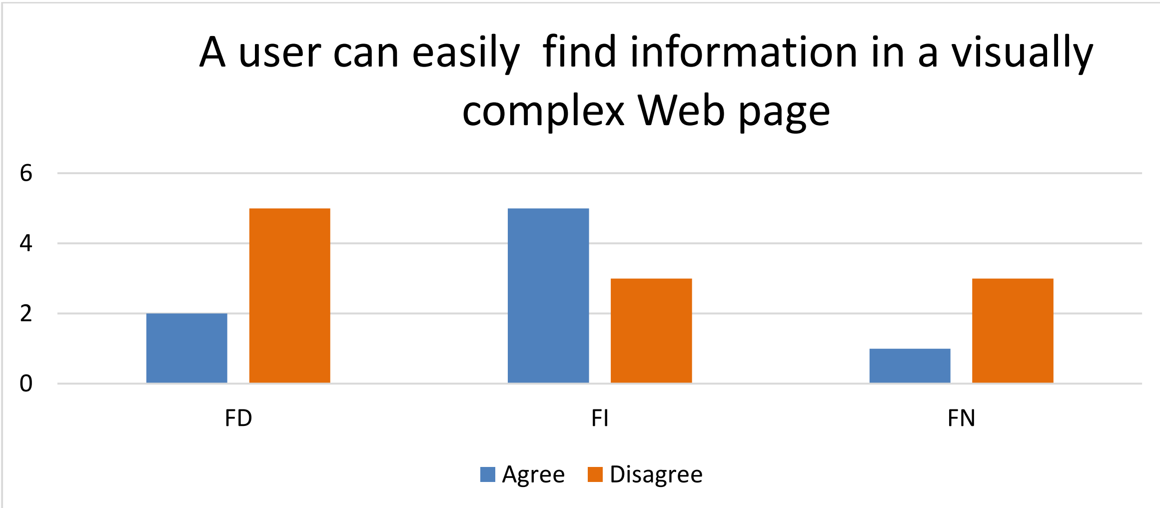


Figure 18: Classification of the answers given in the question: A user can easily find information in a visually complex Web page based on cognitive groups

The results of the above figure demonstrates 5 users from the FI cognitive type group to agree that a user can easily find information in a visually complex webpage. The study can understand this reaction from FI group because their opinion is supported by the best performance in time completion tasks even in visually complex websites.The same reasoning can be used to support the FN group that similarly performed good times in time completion task.

The contratiction though relies on the two users of the FD group that even though they had classify as FD, considering they had the slowest times (on average) in time completion test, they had agree that it is easy for a user to find information in visually complex web page.

After a further analysis made on the raw data it had been found that those two answers have been given by two users that are graded very close to FN group. From this finding the study can justify their reaction. Since we already know that FN group sometimes react as the FI group while other times react as FD group. Then it is possible for the FD users that had scored close to FN group to behave similar to FN. Moreover, based on the data collected from this study it can be claimed that a user usual behaves based on his perseptual style, however during the study they were cases that users had performed much better than the average scores of their cognitive group (for example FD and FN users). On the other site they have been cases that users had performed lower than the expected behavior of their cognitive group (for example FI users).

4.2.1 Statistical Analysis

The first statistical analysis was made based on the results of time completion task between the cognitive groups. The hupothesis set in the study is as shown below and the test had run with alpha 0.05, this means 95% confidence level:

H0: $\mu1 = \mu2 = \mu3$
H1: at least one of the means is different.

SUMMARY OF ALL GROUPS REGARDLESS COMPLEXITY LEVELS

Groups	*Count*	*Sum*	*Average*	*Variance*
FN	4	969	242,25	2712,917
FD	8	2035	254,375	1072,268
FI	8	1732	216,5	655,7143

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5886,575	2	2943,288	2,472786	0,114121	3,591531
Within Groups	20234,63	17	1190,272			
Total	26121,2	19				

In our study the *p*-value is greater than alpha. In this case the study fails to reject the null hypothesis. This means that the study results are not statistically significant due to the small sample.

In a further analysis the study had tried to the correlate cognitive abilities with the level of complexity and the time scored in Time completion Task. All the scores showed p-value to be greater than alpha which means that our data are not statistically significant (the results can be found in the Appendix) this happens because of the small sample size.

4.3 Visual Complexity

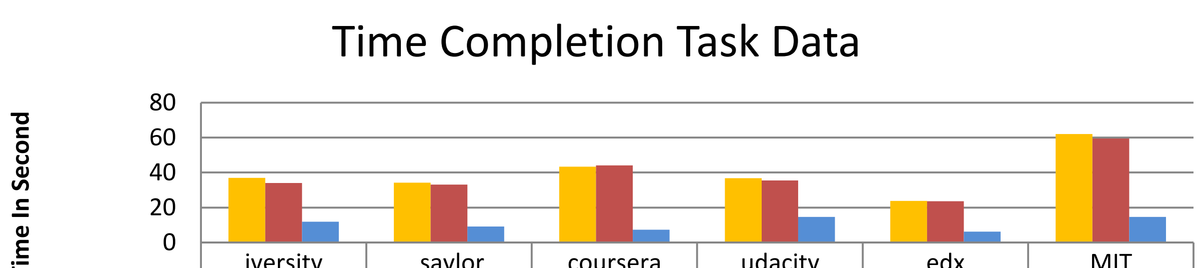
During this part of the study it would be investigated the correlation of an individual cognitive abilities in terms of FD-I dimension with the complexity level of a website. Based on what it is already stated the complexity level of the websites had been analyzed with the ViCRAM algorithm. The outcome of the algorithm it is based on the following formula: Visual Complexity = 1.743 + 0.097TLC + 0.053W + 0.003I

Where (TLC) is the count of top left corners, (W) stands for word count and (I), the image count. The ViCRAM scores for the study are represented in the next table with the right most column to stand for the overall time that it took for an individual regardless his cognitive group to complete all of the tasks. The time needed for completing the three tasks within a webpage have been summed up because the webpage used for the three tasks was the same in each website.

Websites Complexity Level (ViCRAM) vs Time Completion				
P.ID	**Website Name**	**Complexity Score ViCRAM**	**Complexity Level**	**Average Time Regardless Cognitive Type (all Tasks)**
6	UDACITY	2.0670	Simple	36.7 seconds
21	MIT	5.4530	Medium	61.95 seconds
23	IVERSITY	6,5789	Medium	36.9 seconds
24	COURSERA	7.5926	Medium	43.4 seconds
29	EDX	10.0	Hard	23.75 seconds
27	SAYLOR	10.0	Hard	34.1 seconds

Table 7: Websites Complexity Level and Time Completion Scores (See Appendix for extended version)

Additional, in the next graph are presented the average time needed for an individual to complete the time task per website, the mean value and the standard deviation for each website.



	iversity	saylor	coursera	udacity	edx	MIT
Average Time	36.9	34.1	43.4	36.7	23.75	61.95
Mean Time	34	33	44	35.5	23.5	59.5
S.Deviation	11.91	9.19	7.33	14.56	6.23	14.63

Figure 19: Other Data related to Time Completion Task

From the extensive figures displayed in the previous graph (Figure 19) the study compared the average values of the users with the Median Value for the respective websites. It had been identified that the average user performs (in general) slower than what it was expected based on the Median Value. The only exception was Coursera website, where the users had performed better than the Median Value. What this means; is that in Coursera website users performed better than what was expected to behave, even though the specific website considers being a medium to hard in terms of visual complexity. Regarding the rest of the websites they had scores around the expected behavior.

More importantly, the above figure (Figure 19) shows the standard deviation of users' within the respective website. The standard deviation as it gets smaller it becomes more possible for future users to find their score closer to the mean value. On the other hand a high standard deviation indicates that the data points are spread out over a large range of values. For example in the MIT website a user had completed all the tasks in 85 second while another user for the same website manage to finish it in 44 seconds. This distance between those two users is represented by the standard deviation.

The next graph are illustrates the time trends that exists between the complexity of each website classified by cognitive groups. The scores in the vertical bar represent the time it took for users to complete Time Completion Task.

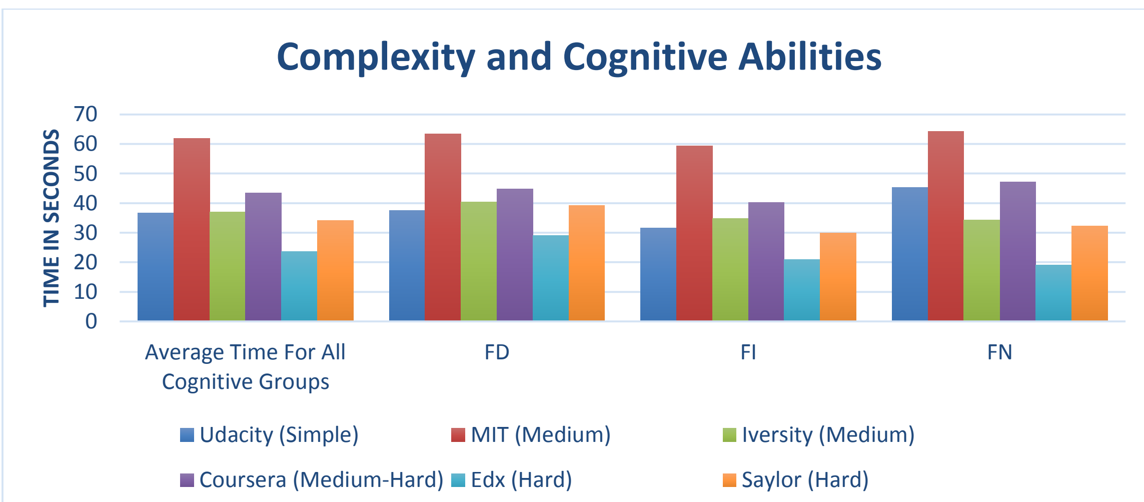


Figure 20: Perseptual style vs visual complexity

The first thing to notice from the above figure specially if you compare it with the table 7 is that the ViCRAM algorithm does not fully correlate with the time completion task. A finding that proves the above statement relies in the case of MIT website. The specific website was calculated to be of medium complexity status but the users had the hardest time processesing the content of this website.

This behavior was not expectred by the researcher who initial expected to receive a linear relathsionship between time completion task and the calculated visual complexity.However, it was soon realized by the researcher that, the ViCRAM algorithm produce a figure solidly based in its formula. They are a lot of other parameters that the ViCRAM algorithm does not take into consideration. For example the use of Cascading Style Sheet (CSS), Javascript, coloring patterns, fonts and more importanly the site structure. All of those factors who actually affect the user perception need to be included in the estimation algorithm of visual complexity.

To get a better understanding of the relatathionsip between cognitive abilities in terms of FD-I dimension and visual complexity the study choosed to investigate specific websites in isolation. The first of the websites to be investigated is the Udacity website which has been charactirized in Table 7 as a simple complexity website.

By observing the figure 21 it can be seen that FI group performs as expected; quicker than the other groups. Nonetheless, FN group which was expected to had the second best performance had been overtaken by FD Group .

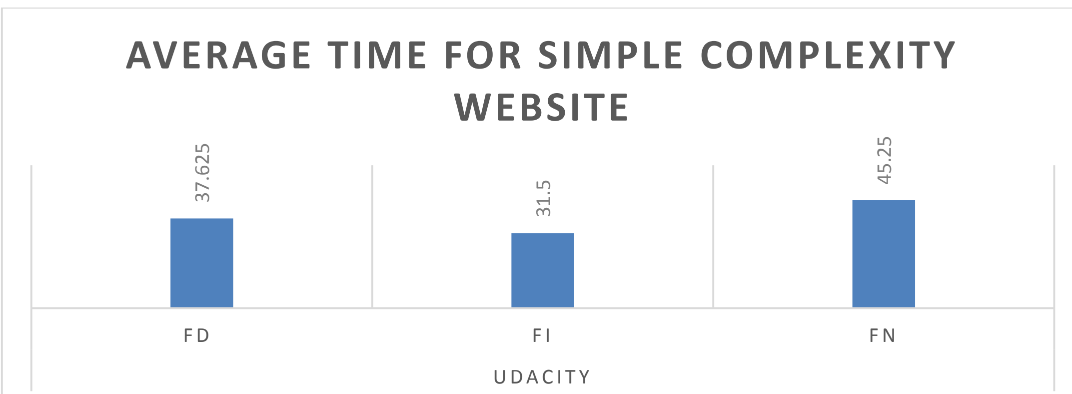


Figure 21: Average Time to complete all the tasks in the website Udacity categorized by cognitive groups

The behavior of the cognitive groups as they have been presented in figure 21 develops a lot of queries regarding the relathionship that the study explores.

Some of the questions that need to be answered are the followings:

1. Why in a simple complexity website FD users perform better than FN users ?
2. Why FD group performs similar to FI group in a simple complexity website ?
3. Does it justified as simple complexity webpage the time needed for completing all the tasks ?

To take things in turn the study started with the first question. For the first question it is believed that the FN group did not had a strange behavior. It was obvious from previous observations that the FN group performs in all the range of possible values (see Figure 19, Standard Deviation for Udacity). That is why sometimes gets better times than the FI group while other times get slower times than the FD group. However it must be mention that for the FN group the trends are changing while the complexity raises. This is a finding that will be presented when analyzing figure 22.

The answer to the second question has to do with the visual complexity. The fact is that for simple complexity websites the scores regardless the cognitive groups are good. This finding means that users regardless their cognitive groups can easily find objects within a simple complexity website, thus it can be assert that users will have a more pleasant navigation and experience.

Regarding the last of the three questions it is supported by the study that all of the groups could had perform better than their actual scores regarding the specific website. Actually it was this website that most of the users had completed the first two tasks very quick and had a lot of delay in the third and last task. This behavior of users during the Time Completion Task would be analyzed in figure 26.

In the next figure the study will present two websites that they have been classified as the most complex to be processed by the user.

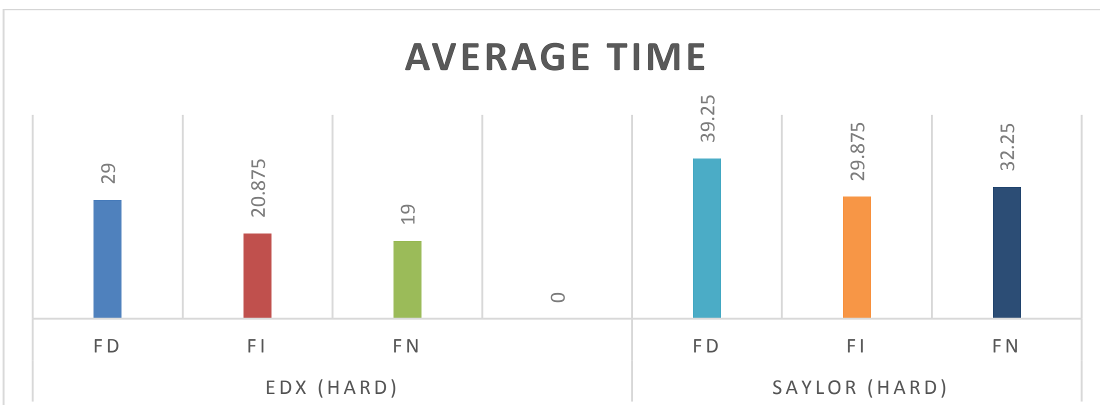


Figure 22: Average Time of Cognitive Groups in the most complex websites.

The first finding from figure 22 supports the second answer given by the research in the analysis of figure 21. As it can be observed FN users perform better as the Complexity level raises.The first case of complex websites to be explored is the EdX. In the EdX website the FN users had perform better than the FI users who are being consider as the fastest of the groups. In the Saylor website even though FN group competes very close to the FI, the FI group had managed to overtkan the FN but with a small distance between the two groups . Either way though, the finding that it is important to bring up is that FN group performs well when the visual complexity it is consider to be complex.

On the other hand FD user who had perform better than FN users in the simple complexity website (figure 21) they seem to struggle processing the content of websites described as visually complex.

The next consept to be presented is the absolute distance in terms of time between the groupd FD and FN. The data regarding the comparison of the two groups is presented in the table 8:

	Iversity	Saylor	Coursera	Udacity	EdX	MIT
Complexity Level	**Medium**	**Hard**	**Medium**	**Simple**	**Hard**	**Medium**
Average Time FN	34.25	32.25	47.25	45.25	19	64.25
Average Time FD	40.375	39.25	44.75	37.625	29	63.375
Distance Of Two Groups	-6.125	-7	2.5	7.625	-10	0.875

Table 8: Displays the distance in terms of time between the FN and FD group for each website investigated.

Taken into condsideration the findings of Table 8 it can be distinguished that FN users in total sum, perform much better than FD users. The reasoning behind the above statement shows that FN users when outrunned the FD users had a time distance of 23.25 seconds. Whereas FD group when outrunned the FN group had much smaller time distance (11 seconds) between them. This piece of information give you an idea about the difference in cognitive abilities in terms of FD-I dimension between those two groups. Also it is important to note that each group (FD or FN) had outrunned the other equal times. The secret though in an analysis relies in the detail, therefore the study searched to find which was those cases that each group outrunned the other.

From the table 8 it can be distinquished that FN group had out runned the FD group when the complexity was considered more visual complex. Whereas FD group had outrunned the FN group when the complexity was visualy simple. This is another finding of high significanse because it clarifies the difference between the cognitive groups.

To create a more holistic view of the cognitive abilities in terms of FD-I dimension of the participants, the study will involve in the analysis complexity figures and figures of the FI group. It must be mention though, that there would not be a comparison between the FD and FI group. This decision was taken because FI group out performs FD group in every website the study had analyzed (see figure 20). The cause of this effect relies in the difference between the cognitive abilities in terms of FD-I dimension of those two cognitive groups. It can be assert that FI group has stronger cognitive abilities in terms of visual attenton in regard to FD group.

Consequently the analysis will focus on the FN and FI group. For the study to has valid result in the comparison of those two groups it must monitor the trends between the groups while the complexity of the webpages changes. In the figure 23 would be demonstrated the Time scores of each cognitive group in a classification based on website complexity .

If someone see the figure 23 very quick he can easily draw the conclusion that FI users perform better than FN group in overall. However they are cases ,such as EdX website and Iversity website where FN group performs even better than the FI group. This result acts like a revalidation of the previous claim that FN group can perform than FI group under some circumstances. One of those being the posssibility of having a more complex environmnent.

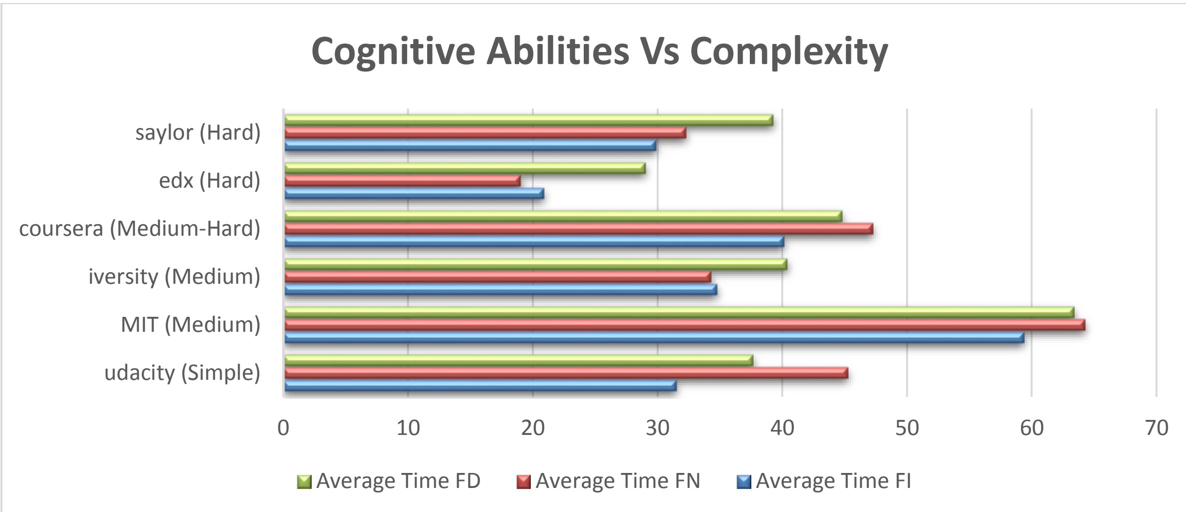


Figure 23: FN and FI group comparison of perseptual style versus the website complexity.

In an attempt to analyze how an average user within the FN group would perform while the complexity changes from Simple to Hard the following figure has been developed.

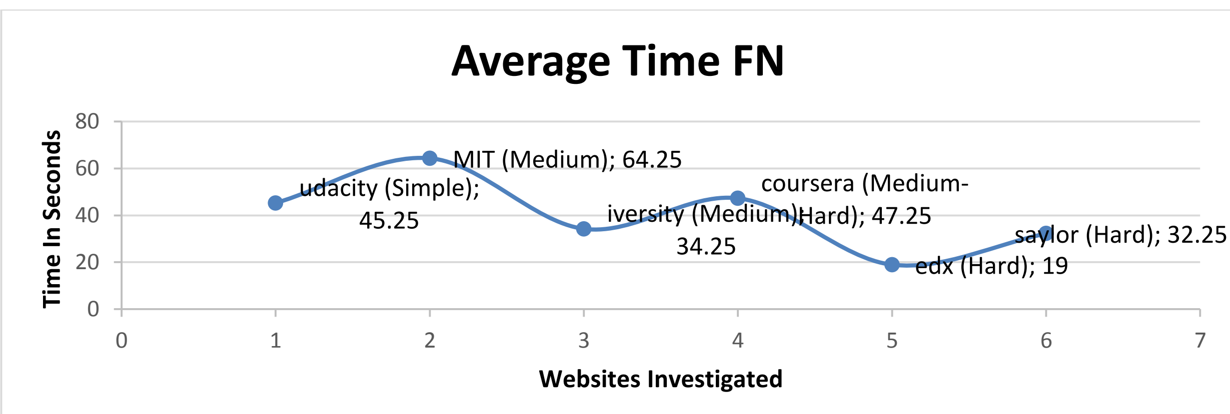


Figure 24: FN Cognitive group vs Complexity

The figure 24 illustrates the claim that as the complexity changes from simple website to a more complex (see the graph from left to right) the FN group manages to perform better times.On the other hand by viewing the figure 25 which is the FI group timeline representaion it can be demonstrated the speed and constant efficiency that this groups identifies objects within websites, regardles their complexity.

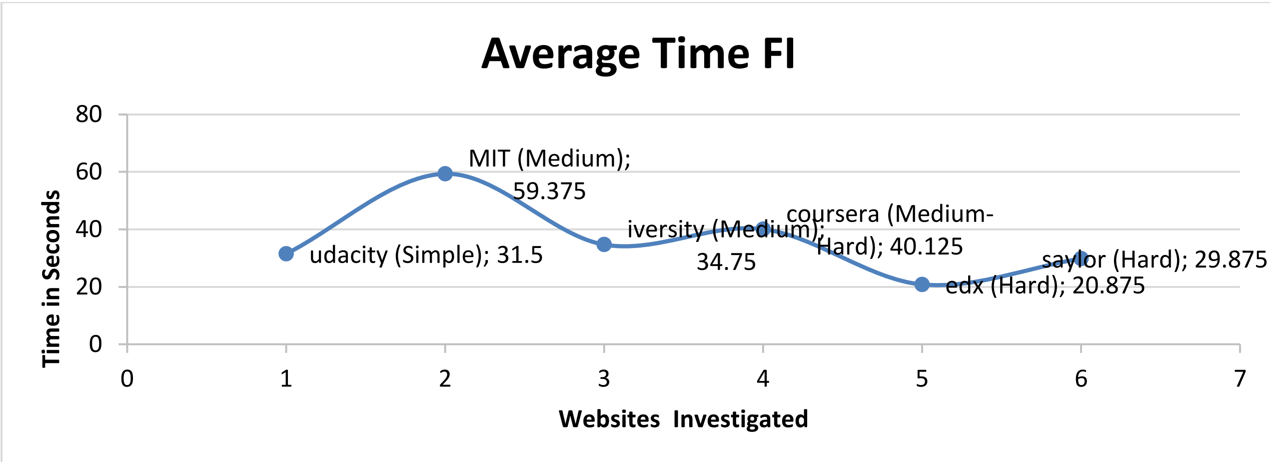


Figure 25 : Figure 24: FN Cognitive group vs Complexity

In the study are included qualitative data that have been taken from the online questionnaire and describe the motives of the participants' rankings in regard to what they perceive as visual complex. In the next table it has been created a summary of those attributes that if found in a website they perceived by the participants as visually simple or visually complex.

How would you describe a visually simple page?	How would you describe a visually complex page?
Less boxes and less textual content	Too much textual content , complex geographical elements
easy to find info on basic structure	multiple information links, no easy to understand structure
Most important information are prominent and clearly visible, good use of whitespace, clear and uncluttered.	complex structure with hard to find info
Each Link category must be represented with the relevant icons.	Too much information and clutter, bad design, not giving visibility to important information.
bright colors, medium fonts, with pictures	Too much text links.
light colours not much content easy to navigate	small fonts, small letters, compress subjects, no pictures or colours
Combination of Fewer choices, items grouped by theme, No color clashes.	too much scrolling
Clear fonts, Tabs to separate subjects and material. Not lengthy that will involve too much scrolling.	A lot of menus, images, and moving things at the webpage
Organized, not too much info, no complex colorings. Consistent throughout - 1 - 2 menus at most	too much info, not consistent - different font sizes different colors, many sections

Table 9: Qualitative data from the online questionnaire

In respect to the data provided by the table 9 the study supports that the participants had expressed more or less the same principles regarding what they perceive as visual complex. So if they share a common view of what complexity means then the items they had identified as complex they probably are. However the study cannot measure with the materials used in the study the degree of difficulty the participants had on the elements they recognize as complex. Nevertheless it is valid for the study to assume that the degree of difficulty would be according to the perceptual style of the user.

Into an attempt to analyze the attributes that create a complex website the study had created a table where it compares the EdX website (best times in Time Completion Task but graded as Visual Complex by ViCRAM) with the MIT website (had the longest time in Time Completion Task and graded as medium complex website by ViCRAM). In the comparison are included the attributes that ViCRAM algorithm uses to formulate its results and the some of the attributes users value as complex.

Web site Attributes						
Page	**Words**	**Fonts**	**Structure**	**Color**	**DIV**	**Images**
EDX	5186	One font in grey color using large size fonts for readability.	Simple Structure Basic set of links on top of the page and the frequently used links are placed at the right or in the footer.	Consistent colors in similar tone. Easy for user to read.	51	2
MIT	665	Inconsistent fonts, somewhere small and in other places big, color of fonts changes often (grey, black, red, blue)	Complex Structure (dropdown menus, too much links, too many images). Hidden areas ex. text areas that change based on tab button	Inconsistency with colors, a large variety used.	249	27

Table 10: Comparison of Visual complexity within EDX and MIT.

The numeric values such as word count, div count and Image count have been estimated from the page source of each website (see table 10). From that data the researcher tried to make a draft estimation based on the ViCRAM formula the complexity within those websites.

Complexity = 1.743 + 0.097TLC + 0.053W + 0.003I

MIT= 1.743 + 0.097*(249) + 0.053*(665) + 0.003 * (27) ➔1.743 + 24.153 + 35.245 +0.081=**61.951***

EDX= 1.743 + 0.097*(80) + 0.053*(5186) + 0.003 * (2) ➔1.743 +7.76 + 274.85 +0.006=**284.35***

Those scores are not the real they used as a draft estimation of visual complexity

Putting it all together the study end up with the following table :

Website	ViCRAM	Draft Estimation	Time Completion Task
MIT	5.4530	61.951	61.95 seconds
EDX	10.0	284.35	23.75 seconds

Table 11: ViCRAM vs Time Completion vs Draft Estimation

As it was expected both ViCRAM algorithm and researcher estimations based on div's, word count and images show EDX website as more complex than MIT. This finding validates the results of ViCRAM.The mystery though is that EDX was the website that users regardless their coginitive ability had completed quicker than the others even though that it had much more texting than MIT or other websites.

The reason why EdX n had better results than the MIT and the other websites come after the analyzis of the qualitative data. The only possible explanation that can be given is that the results are due to the structure of the website.

MIT website (see Appendix:MIT Screenshot) it is a four colunm website with a banner, top colunm, right and left colunm and footer whereas EDX is a three colunm website. Additionally in the EDX website the user knew where to find the links he was asked to find. The menu 's of the EDX website where placed in obvious sections like top bar and right bar. Where as the MIT website had too much information within a complex structure who was accompanie of bad taste in fonts and their coloring. Even though it seems a smal detail it is actually one of the reasons that participants dissorganized within MIT the fact that it had different font sizes and different font colors.

Another aspect that created additional complexity is that the MIT website had many colors in the background and tried to provide too much information. For example it used a series of dropdown menus that created the need for the user to remember the choises it had within each dropdown so that he could found the item he was searching.The fact that EDX website had too much text in the main colunm and a lot of scrolling did not affect the users when searching for objects. The reason is the simplisity of the structure but also because the words in the main colunm where easy readable and they had one font, in a large font size.

Notheless the large text areas and the scrolling are expressed by participants as elements that increase visual complexity. To sum up, the finding which is of high importance is that the structure of the website it is more important than the texting, even though the word count considers to be a crusial factor in visual complexity.

As a result the study ring the bells regarding the need of use Cascading Style Sheet (CSS) in the design of a website in order to have more aesthetics and better website structure, such an example is the website Udacity. The score of Udacity from ViCRAM represented a simple website, it achieved that from minimizing the text and div's within the page but also was able to provide good aesthetics via the use of CSS. The website had limited textual figures, image and it is much more appealing website than EDX and MIT even though Udacity is a four colunm structure website it looks simple. What this finding shows is that even through a complex website structure, the developer if it uses good CSS practises it can create an apealling website, with simple complexity.

Another important aspect that needs to be evalueated, is that the first two objects where found by participants very quick. Actually if the study it was to evaluate the website for the two first objects the Udacity would had the best scores in time completion task. However there was a third object to be found Udacity and it was that Object that gave the delay for the users. The researcher who had observed the participants, realized, that this website was the only one that users had search within it twice or even more times from the top up section to the bottom and they still couldn't find the object they were looking. The study supports that this had happened due to the background the item had in contrast with the white color text. When the users finally found the object they were looking for, they were very impressed because the object was always in front of them but they could not see it.

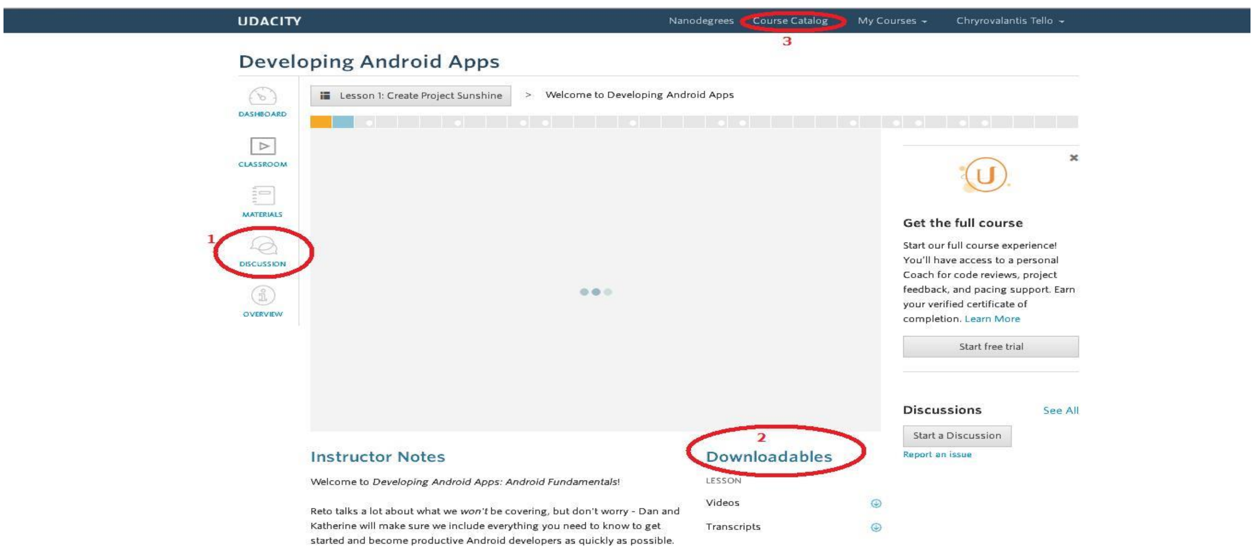


Figure 26: Udacity page. In Circle the items the users was searching for in Time Completion Task.

After investigating the Udacity Webpage the study had realized that a high value finding was hidden. The study was able to bring this finding into the light and demonstrates the high importance of colors within a website. The study based on the findings it had believes that the colors play a tremendus role not only in the aesthetic part but also in terms of functionality and moreover in terms of visual complexity. For the next step the study choosed to inspect the rankings given by the user in regard to webpage complexity. The next table displays the data collected (The higher the number in ranking the more complex the website had been perceived):

P.ID	WEBSITE NAME	RANKING OF COMPLEXITY	INCLUDED IN TIME COMPLETION TASKS
1	Coast Communities	88	NO
3	Coursera Forum	83	NO
6	Udacity	58	**YES**
11	Coursera Grading Assesments	72	NO
17	Udemy	90	NO
21	MIT	98	**YES**
23	Iversity	51	**YES**
24	Coursera Cryptography	78	**YES**
25	Coursera Class Resources	93	NO
27	Saylor	83	**YES**
29	EdX	69	**YES**
31	Open to Study	90	NO

Table 12: User Rankings

Additionally it has been created a graph of the above chart for better understanding and comparison between the webpage.

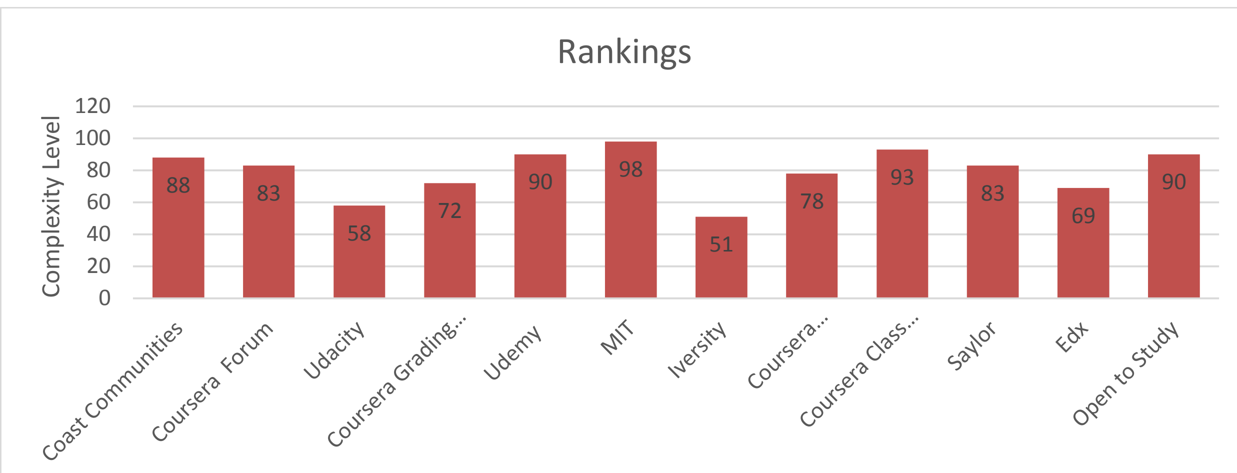


Figure 27: User Ranking in graphical represantion

As it can be observed by the figure 27 the educational environments (websites) of Udacity and Iversity which has included in the time completion tasks had valued with as the lower visual complex websites. However the ViCRAM algorithm had calculated the Udacity as simple while the Iversity has been calculated as Medium complex website. It must be mention though that those two educational environments had similar times in Ime Completion Task. Additionally in the Appendix can be found (**Screenshots 4,5,6,8**) 4 different cases of mousetracking within the Udacity website that justify the assumption made above for figure 26.

In the Case of Saylor and EdX websites which have been calculated by the ViCRAM as the most complex educational environments in our sample they had received values from participants that sets them in the Medium to Hard level for Saylor and Medium complexity for EdX.

On the other hand MIT which has been calculated as a Medium complexity website by ViCRAM it has been perceived from participants as the most complex educational environment. The last is case of Coursera forum where the ViCRAM algorithm had correctly identified the visual complexity of the site as Medium. In the Appendix section can be found screenshots of the users tracking performance, in the case of FD within Coursera website it can be observed that the user had performed great cognitive effort for identifing the object(**Screen Shot 3**). This can be assert from the number of lines drawn by user mouse. On the other hand other users within other cognitive group had better times and less moves within the website for identifing the object.

Another important finding that was revealed by the four different Coursera sites (in the user questionaire) was that even though they had the same structure and colors they had received different scores. The study justifies the difference in scores because each website tried to deliver different amount of information to the user. That is why the Coursera Class Resources had received the higher value in regard to complexity , it is due to the excess amount of information it had.

4.3.1 Aesthetic Suggestions

Based on the user ranking but also the qualitative data collected by the study. The author tried to identify elements within websites that may affect the visual complexity. The table below displays the findings:

Attributes that affect the visual complexity	
Website Structure	**Number of words within the website**
Choice of Fonts	**Choice of font Color**
Choice of website colors	**Use of CSS for displaying DIV**
Number of Images	**Metadata on Images and Links**
Navigation Menu	**Footer Size**

Table 13: Attributes that affect the visual complexity

Furthermore, based on the data collected and the findings revealed in this research, the study had developed a series of advices that targets the website developers and quide them on attributes that would affect the user experience.

Website Structure: The developer should develop a website in a minimalistic form, this study had showed that a two colunm architecture with a top bar of links is very efficient for the user. Structures like the once found in Udemy or MIT (see figure 27) should be avoided.Figure 28: Website Structure

Number of words within the website: The ViCRAM algorithm suggests fewer text per page. This finding has been validated by the participants and it been demonstrated that most of the pages that have excess text have been graded as visually complex. Such an example is the Coursera Class Resource (see finding 27).

Complexity Relationship with Text

P.ID	Website Name	Complexity Score ViCRAM	Word Count
6	UDACITY	2.0670	264
21	MIT	5.4530	665
23	IVERSITY	6,5789	112
24	COURSERA	7.5926	class site is currently closed
29	EDX	10.0	5186
27	SAYLOR	10.0	658

Table 14:Relathionship of Text and Complexity

As it can be observed by the table 14 the complexity relationship is related to the volume of text that exists in the websites. It can be seen that the complexity increases as the volume of text increases, however exceptions occur in the current trend such an example is the IVERSITY website. The reason that the IVERSITY website has been excluded is because of the successfully implementation of CSS and the minimum amount of text in the central screen. The example of IVERSITY represents a good practice that should be used more often in websites.

Choice of Fonts: Based on the study and after analyzing the fonts that have been used in the 30 websites analyzed by ViCRAM the study came up with a combination of fonts that the study considers as appropriate for websites, the fonts are the followings:

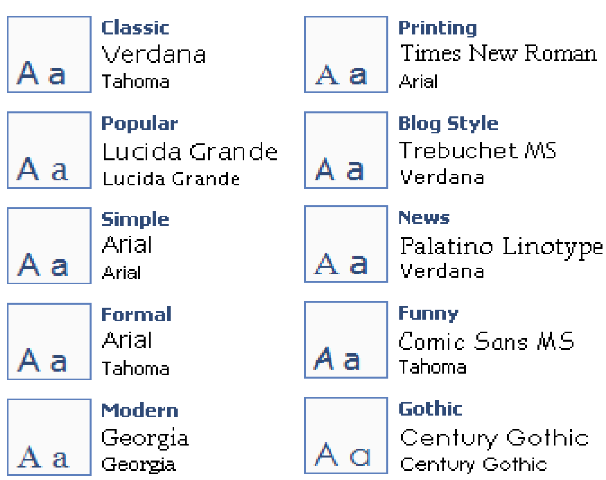


Figure 29: Appropriate fonts to be used

The fonts have been presented in categories that targets the purpose for which the fonts should be implemented. Other cases of good fonts exists and have not been included. From the figure 29 the font name shown first targets the heading of an article and the second font targets the body of the post. One of the benefits of the fonts presented in figure 29 is that they can be presented by any browser, in comparison with other fonts, such as google fonts that need to be loaded each time the page opens and create performance issues for the website.

Font Color and Website Colors: Font colors need to be coherse with the overall color pallet that is been used in the website. Often websites have black color fonts on a white background in the main text area. In this study cases like EDX had shown that if the text in a website has big fonts then the user can clearly read the content and it can find objects within such a website. Regarding the color of the fonts the study can not provide guidelines on which colors to use. However as an advice based on the findings of the study, developers should try avoid compination of strong colors (ex. MIT website). Developers should seek to identify colors that make the eyes to relax such colors are white or similar colors, grey or similar, light orange or blue.

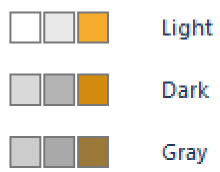


Figure 30: Different color tones of the same colors.

Use of CSS for displaying DIV: One of the reasons websites had scored high in ViCRAM is because they had too much texting or too much shapes within the website. With the use of CSS the big text areas can be avoided and a lot of information can be presented to the user with out being annoying. Such an example is the Iversity website which manage to create a tabular menu for each chapter and in there to provide more information. Below is shown a screenshot from the Iversity website:

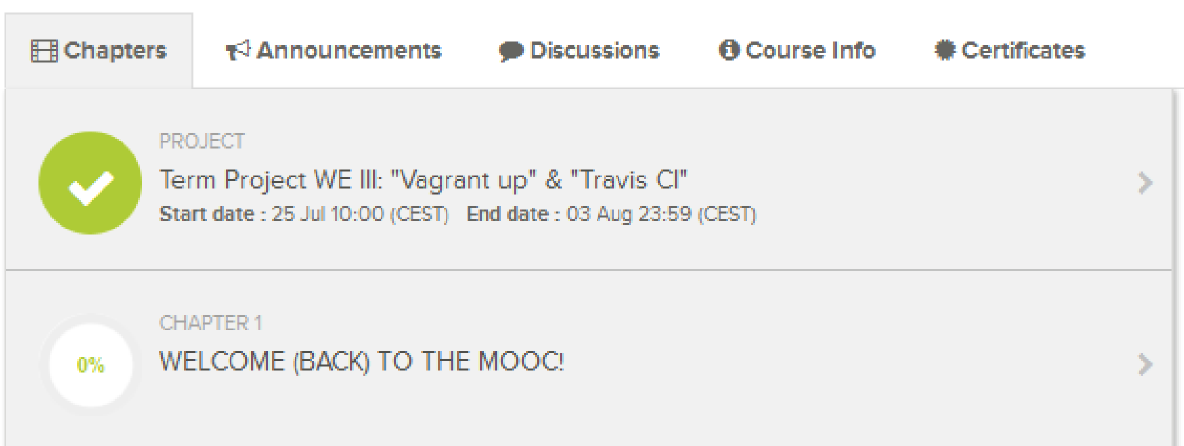


Figure 31: Iversity Website with tabular menu.

From the websites analyzed and the observation made during the time completion task. A rule of thumb can be generated which supports the use CSS for better aesthtics. For example the above tabular menu had used Javascript and CSS to present too much textual figures in a nicely form, this effort had been awarded with a more friendly website for the user . Otherwise the non use of CSS would have cost to the webpage to load excess amount of text in the main colunm.

Number of Images : From the qualitative data had been figured that too much images create visual complexity. Based on participants instructions it can be claimed that an excess amount of images create visual complexity, however as “they said” small icons on top of articles decreases the complexity and may explained to the user what the link does. An example of that aproach can be seen in figure 31,,the iverity website uses small icons on top of each tab.

Description on Images and Links: By observing the users while performing time completion task it has been observed that users before clicking on a link or an image they wait for few seconds; the researcher believes that they do so because they expect more information regarding the link they are about to press. Therefore it is a good practise for a developer to add, in each link or image a short description. Beyond the functionality that this process offer, the developers should expect a better rankings on search engines since they value meta data.

Navigation Menu: From the results of the study it has been found that users react better with simple navigation menus. In case like MIT which had an advanced menu users had spent a lot of time trying to check each of the links placed inside the drop down menus. Contrary to other cases where the menu bar had only simple links (Udacity,Iversity,EdX) the users had better experience and therefore they were able to find objects quicker. This figure can be observed in the user tracking data within the Appendix, it was found that in complex website users need to make more mouse moves than in other websites. Consequently based on the results the study believes that it is better to avoid the use of dropdown menu’s and prefer the use of simple buttons or links in an either horizontal bar or colunm menu.

Footer Size: Footer size should be small and hold a limited amount of information, in cases where the footer was big and had too much information the footer start reacting as another horizontal colunm in the eyes of the user. Such case has found with the MIT website which had too much information in the footer. Eventually the users had spend more time checking the footer rather than the menu’s or the main colunm of the website.

Chapter 5

5.1 Discussion and Conclusions

The study was set out to explore the relationship between user's cognitive abilities in term of the FD-I dimension and their visual perception while browsing web pages. To do so the study had set up a framework of similar websites (with all of them being educational and used for online learning) from which it had extracted their Complexity with a complexity analyzer tool named ViCRAM. Those complexity scores had used later on for comparison of user cognitive abilities in terms of FD-I dimension within the websites selected for investigation.

In the meantime, the study had classified the users based on their perceptual style with the help of Hidden Figure Test. The users were classified in three categories: Field Dependent, Field Neutral and Field Independent. The Field Dependent (FD) users differ from the other classifications because in a distracted environment they will face difficulties in finding out what they are looking for due to the inability to separate parts of a whole. On the other hand the Field Independent (FI) users have the ability to focus on the relevant details and not be distracted by unnecessary details. Between the two classifications relies a third category the Field Neutral (FN) users, they can focus on the relevant details in a mild distracted environment and they have the ability to react sometimes as FI users and sometimes as FD in order to complete their tasks.

Having calculated the complexity scores for each website and classify user's perceptual style, this study asked participants to complete a task where they had asked to find specific objects within a sample of webpages. The objects that the participants were looking for shared the same difficulty among the websites. Based on a parameter such as the time, the users within each of the cognitive groups had been compared for their efficiency to identify objects as the complexity within the sample pages increased (samples of mouse tracking data can be found in the appendix).

The study was able to compare and draw conclusions based on the ability of each cognitive group to react in educational environments (websites) of different complexity levels. The linkage between the cognitive groups and complexity has been achieved through monitoring the time needed for time completion task. The mouse movements by themselves couldn't demonstrated repetition or any kind of trend between the users so that efficiently the author could have drawn valid conclusion from.

From the study important findings had been found regarding the behavior and visual perception of each group. As it was found each group received and processed the information different than the other group. Significant difference among the groups has found to be the time needed for each group to process the information as the complexity variable changed among the websites. This finding is in line with a recent study that has found differences in simple and complex webpages between field dependent and field independent users [160,161]. The methodology used, had eventually brought to the surface important insides on the cognitive effort that is required by a user based on his perceptual style to interact with websites.

The results of the study had answered the research questions as those had been set from beginning of the research. Firstly it has been revealed that complexity affects the cognitive effort in many ways. The study showed how complexity affects the cognitive effort by asking users to find objects within webpages; the results showed different times between the users therefore different cognitive efforts. More specifically it has been found that the visual complex pages required more cognitive effort since the user needed more time for finding an object in contrast with a simple complexity page. Therefore it is valid to claim that visual complexity not only affects the perceptual style of the user but it determines the cognitive effort of the user.

For determining the cognitive ability in terms of user perceptual style (FD-I dimension), the study had run separate procedures such as classifying user abilities in terms of their FD dimension, monitoring their web behavior, analyzing the complexity level of the websites been investigated and finally correlate those procedures.

Of course the most important factor that eventually co-determines the web experience it is the user own visual dimension. As it has been found, having an FD user interacting with a website has a lot of difference than an FI user. Consequently the need exists for the developers to develop websites that suits all the cognitive groups.

This result can be achieved by simplifying the structure of the website but without losing the functionalities that the website had to offer at the first place. Regardless though of the cognitive dimension of the user it has been found that specific attributes affect the user's perceptual style.

Such attributes seems to be the words, the images, the fonts and more importantly the shapes that exists in a website. By the term shapes the study does not only refer to the physical objects that may exist in a website but also to the logical shapes (structure) that build up a website. The structure of the website create the logical framework in which a user will search the information he needs, some of the most often used structures are the main column, two column structure and three column structure. From the findings of the study it can be assert that since the cognitive dimension of a user affects his ability to process shapes, based on the findings of Hidden Figure Test, then it is expected from a user (based on his cognitive dimension) to have difficulties in processing the logical shapes that exist within a website.

Thus it can be claimed that as the logical shapes increases (for example a three column template) the cognitive effort of the users' increases too; this increase in the cognitive effort does necessarily represented by the complexity algorithms used for determining the visual complexity.

Such a tool (visual complexity calculator) is the ViCRAM algorithm that has been used for calculating the website complexity, in those tools an algorithm formulates the results given that specific objects are considered complex and if found in website would increases the website complexity.

In ViCRAM algorithm a high importance had been given to the number of DIV's, specifically those that their left upper corner cross joins other DIV's. Even though that this is not wrong as an idea the truth is that a lot of things had changed in the way websites are built today. The changes in the development of websites have been in such extent that the number of DIV's within a website may not represent (in some cases) the real complexity level.

For example a website that has 20 DIV's does not necessarily being more complex than a website that has 10 DIV's; this is happening because of the extensive use of CSS and JavaScript within websites. Those tools had given the ability to the developers to develop visually friendly websites even though they may have excess number of objects within the website.

5.2 ViCRAM Suggestions

The results of the study regarding the complexity had showed that ViCRAM algorithm needs to be upgraded. They are lot parameters and attribute that needs to be included in the formulation of complexity based on the findings of the study. Moreover the current algorithm has some gaps in the way it calculates the complexity level.

Point 1

The results from the HFT demonstrated that a framework of shapes produce some sort of complexity. From this finding it can be assert that a framework without any objects has zero complexity. Therefore with every addition of an object within a framework it is inevitable that the complexity will increase.

Taking as a fact that the above assumption is correct, it can be claimed that more objects should be taken into consideration beyond the word count, DIV's TLC and image count.

The study suggests the addition of the more attributes within the code of ViCRAM, for example the attributes below (they are too many tags in generally used in a html document; their selection should for the purposes of calculating the complexity should be done based on a separate study) except alt are count in ViCRAM but are not used in the calculation of complexity.

Therefore the study suggests the count of those attributes to be involved in the calculation of complexity based on a ratio for each item. As it was mention during the analysis though, not all items add complexity, for instance, in the case of alt tag which provides textual information for images; this tag should reduce the visual complexity when it is found in a site.

Html Tag	Description
p	Paragraphs
a	Links
table	Tables
ul	List
li	List Items
alt	Alternative Text for image

Table 15: Html Tags need to be added in the ViCRAM algorithm

Point 2

Another significant finding that could help the improvement of the algorithm was identified by observing the users during time completion task and by reviewing their qualitative data. The study had revealed that the size of the font being used and the font type affect the visual perception of the user.

Therefore, the study suggests that ViCRAM algorithm should create a list of recommended fonts (based on literature review, or other studies) and whenever those fonts found in a website the algorithm should not add any points in the complexity sum. On the other hand it should add points (increase complexity level) in the complexity sum when fonts other than the ones suggested being used. Further, the diversity and density of the font styles should be examined and added as a factor in the algorithm, as it is important factor the number of different font styles that a page has.

Unfortunately regarding the font size there is not a valid way to check the visual complexity therefore at this point with the data collected so far the study cannot suggest an improvement. However, it should be marked that font size's play a role in the user visual perception.

Point 3

The current algorithm during its process it counts the divs that have been marked with visible border. The way that the algorithm works it looks for divs that had their border property set up in pixels (px). For example if a border has its border-width: 3px; then it is marked as a visible div.

However this is not the only case that a border has visible border. They are also other ways to make a div visible that the algorithm does not take into consideration. Below are found some common ways to make a div border visible without using numeric expression:

Ways to setup border-width: in alphanumeric representation	
Property	**Description**
medium	Specifies a medium border. This is default
thin	Specifies a thin border
thick	Specifies a thick border

Table 16: Properties that make a border visible

The suggestion of the study is to be included in the algorithm all the possible ways that a div can be made visible.

Point 4

The ViCRAM algorithm as it is right now it counts the images that they are the only child of a node (node in this case id the div). In this way, the algorithm avoids the counting of more than one images within the div been examined. Therefore the study suggests that different ways should be found for counting the images, within the divs.

Point 5

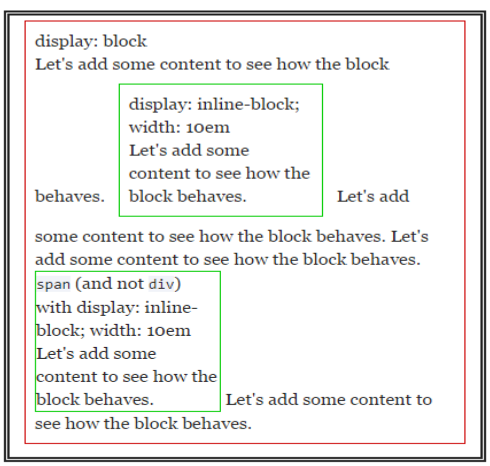


Figure 32: Inline Block

The current algorithm checks specific html elements if they contain at their display property with the value block. The attributes that are being check for their display property are the followings: h1, h2, h3, table, div whereas the html elements <p>,<li>, who can also take in their display property the block are not checked. Additionally the algorithm does not take into consideration the case of having the display: inline-block or display: inline. An example of display inline block is the figure 32

Thus, it is suggested to include all other possible attributes that can be assigned to the property display.

Point 6

At this point they exists many complexity algorithms; although they do not have any input variables they figure the complexity level of a website based on a formula. However, this study had demonstrated the importance of user's perceptual style while browsing educational environments (websites). Therefore it can be assert that a correct complexity algorithm should take into consideration the perceptual style of the user (FD-I Dimension).

That is why a complexity algorithm should, either correlates the weights within the formula based on the user visual perception, a feature implemented in the ViCRAM algorithm, or they should be developed three separate algorithms each one focusing on a separate perceptual style (FD, FN and FI). Only in this way a complexity algorithm makes logic otherwise it is just a tool that counts html elements.

The suggestion of the study is to add the elements previous suggested but correlate their weights based on the user visual perception.

Overall

Beyond the suggestions been described above they may be others too. It is important to mention that those suggestions are based on the current way the algorithm works. The study had also identified that they are a lot of other parameters that the ViCRAM algorithm does not take into consideration. For example the use of Cascading Style Sheet (CSS), Javascript, coloring patterns, fonts and more importanly the site structure. All of those factors who actually affect the user perception need to be included in the estimation algorithm of visual complexity.

Let's take for example the color as a factor which is not included in the complexity algorithm. Imagine for a moment a website that has black background and black fonts, consequently nothing will be visible for the user; such a case cannot be correctly represented by the ViCRAM algorithm because it does not take into consideration the colors. Therefore the study suggests that the ViCRAM algorithm been rewrite with all of the above suggestions but also taking into consideration the results of the analysis made by this study.

CONCLUSIONS

The present study supports the view that individual differences in terms of cognitive abilities in terms of FD-I dimension exist and they affect the visual perception of an individual while interacting with websites. The results of the study revealed significant correlation between the scores retrieved from the HFT and the time needed for completion of time completion task.

It is also worth noting that due to the advances in aesthetic designs in modern websites through the use of CSS and JavaScript some complex websites managed to be processed at closed times with simple complexity websites. Additionally, it must mention that simple – medium complexity websites can be processed regardless the user dimension in a fair amount of time. This demonstrated the need for website developers to follow a framework of guidelines for delivering simple complexity websites. Thus, an improved web experience would be delivered for the user involved in online learning but moreover this can be extent to all websites in general.

Future Work

The study will be expanded by running evaluations with people with disabilities and additional cognitive disabilities, from different academic backgrounds.

In addition further research will be held by the use of eye tracker or mouse tracking technology. To avoid problems of correlating mouse tracking data any future research must use heat maps. In that case it is assume that would be easier to draw conclusions. In the case of eye tracking the researcher can monitor where a person is looking at any given time and the sequence in which their eyes are shifting from one location to another. Hence, a better and more reliable approach will eventually produce a better set of design guidelines, to be used by developers in order to create simpler Websites.

Appendix

Table 1: Summary of 21 usability studies incorporating eye tracking.

Authors/Date	Users and Tasks	Eye Tracking Related Metrics
Fitts, *et al.* (1950)	40 military pilots. Aircraft landing approach.	• Gaze rate (# of gazes/minute) on each area of interest • Gaze duration mean, on each area of interest • Gaze % (proportion of time) on each area of interest • Transition probability between areas of interest
Harris and Christhilf (1980)	4 instrument-rated pilots. Flying maneuvers in a simulator	• Gaze % (proportion of time) on each area of interest • Gaze duration mean, on each area of interest
Kolers, Duchnicky and Ferguson (1981)	20 university students. Reading text on a CRT in various formats and with various scroll rates.	• Number of fixations, overall • Number of fixations on each area of interest (line of text) • Number of words per fixation • Fixation rate overall (fixations/s) • Fixation duration mean, overall
Card (1984)	3 PC users. Searching for and selecting specified item from computer pull-down menu.	• Scan path direction (up/down) • Number of fixations, overall
Hendrickson (1989)	36 PC users. Selecting 1 to 3 items in various styles of computer menus.	• Number of fixations, overall • Fixation rate overall (fixations/s) • Fixation duration mean, overall • Number of fixations on each area of interest • Fixation rate on each area of interest • Fixation duration mean, on each area of interest • Gaze duration mean, on each area of interest • Gaze % (proportion of time) on each area of interest • Transition probability between areas of interest
Graf and Kruger (1989)	6 participants. Search for information to answer questions on screens of varying organization.	• Number of *voluntary* (>320 ms) fixations, overall • Number of *involuntary* (<240 ms) fixations, overall • Number of fixations on target
Benel, Ottens and Horst (1991)	7 PC users. Viewing web pages.	• Gaze % (proportion of time) on each area of interest • Scan path
Backs and Walrath (1992)	8 engineers. Symbol search and counting tasks on color or monochrome displays.	• Number of fixations, overall • Fixation duration mean, overall • Fixation rate overall (fixations/s)
Yamamoto and Kuto (1992)	7 young adults. Confirm sales receipts (unit price, quantity, etc.) on various screen layouts.	• Scan path direction • Number of instances of backtracking

Authors/Date	Users and Tasks	Eye Tracking Related Metrics
Svensson *et al.* (1997)	18 military pilots. Fly and monitor threat display containing varying number of symbols.	• Gaze duration mean, on each area of interest • Frequencies of long duration dwells on area of interest
Altonen *et al.* (1998)	20 PC users. Select menu item specified directly or by concept definition.	• Scan path direction • *Sweep* — scan path progressing in the same direction • Number of fixations per sweep
Ellis *et al.* (1998)	16 PC users with web experience. Directed web search and judgment.	• Number of fixations, overall • Fixation duration mean, overall • Number of fixations on each area of interest • Time to 1st fixation on target area of interest • Gaze % (proportion of time) on each area of interest
Kotval and Goldberg (1998)	12 university students. Select command button specified directly from buttons grouped with various strategies.	• Scan path duration • Scan path length • Scan path area (convex hull) • Fixation spatial density • Transition density • Number of fixations, overall • Fixation duration mean, overall • Fixation/saccade time ratio • Saccade length
Byrne *et al.* (1999)	11 university students. Choosing menu items specified directly from computer pull-down menus of varying length.	• Number of fixations, overall • First area of interest fixated • Number of fixations on each area of interest
Flemisch and Onken (2000)	6 military pilots. Low-level flight and navigation in a flight simulator using different display formats.	• Gaze % (proportion of time) on each area of interest
Redline and Lankford (2001)	25 adults. Fill out a 4-page questionnaire (of various forms) about lifestyle.	• Scan path
Cowen (2001)	17 PC users with web experience. Search/extract information from web pages.	• Fixation duration total • Number of fixations, overall • Fixation duration mean, overall • Fixation spatial density
Josephson and Holmes (2002)	8 university students with web experience. Passively view web pages.	• Scan path

Authors/Date	Users and Tasks	Eye Tracking Related Metrics
Goldberg, Stimson, Lewenstein, Scott and Wichansky (2002)	7 adult PC users with web experience. Search/extract information from web pages.	• Number of fixations on each area of interest • Fixation duration mean, on each area of interest • Saccade length • Fixation duration total, on each area of interest • Number of areas of interest fixated • Scan path length • Scan path direction • Transition probability between areas of interest
Albert (2002)	24 intermediate to advanced web users. Web search for purchase and travel arrangements on sites with varying banner ad placement.	• Number of fixations on area of interest (banner ad) • Gaze % (proportion of time) on each area of interest • Participant % fixating on each area of interest
Albert and Liu (in press)	12 licensed drivers. Simultaneous driving and navigation using electronic map in simulator.	• Number of dwells, overall • Gaze duration mean, on area of interest (map) • Number of dwells on each area of interest

Source: Robert J. K. Jacob and Keith S. Karn [149]

Table 2: Websites examined with ViCRAM algorithm

ViCRAM Evaluation Data

The ViCRAM algorithm's weights on the variables were derived based on a big user questionnaire in order to collect user perception of complexity. In this thesis the data collected for user perception ranking as part of data process and validation. However, the number of sample is not sufficient to incorporate it in the analysis. The data however will be used when a bigger sample will be used (future study already in process)

P.ID	**CoursePage**	**Score**	**Date Accessed**
1	https://www.coursesites.com/webapps/portal/frameset.jsp?tab_tab_group_id=&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_302451_1%26url%3D	0.5955	16/7/2014
2	https://class.coursera.org/crypto-011/forum	1.0464	29/7/2014
3	https://class.coursera.org/clinicalpsych-001/forum	1.0561	29/7/2014
4	http://www.wiziq.com/courses/courseware-learner.aspx?cInfo=MP7Z4Xew36%2foW%2bEGZx6bNMwEShAM8Rj8zm9x4oaiRIkc5DQSsT79LfHa%2fmSw51ZkzW76XL99nXwItCvrEKIB42xv7CrVod47a3%2fNkkRXw0uO5Npk1KdnoQ%3d%3d	1.8006	16/7/2014
5	https://www.udacity.com/course/viewer#!/c-ud884/l-1464158641/m-1473429122	1.8245	13/7/2014

6	https://www.udacity.com/course/viewer#!/c-ud853/l-1395568821/m-1643858568	2.0670	13/7/2014
7	http://www.wiziq.com/courses/course-feed.aspx?cInfo=MP7Z4Xew36%2bTDQtvIP1B9B7DBdOqSfkWdxcHs4aGTBztdoleZd0d9m%2bRcy2vv5nHjh1tsPG75NmFEYV9Prb%2fLUPlzmTYCUkW3Ok0MeMLiA3CvXfa0gE8MQ%3d%3d	2.3358	16/7/2014
8	https://eliademy.com/catalog/catalog/product/view/sku/ac99c85942	2.3870	13/7/2014
9	https://university.mongodb.com/courses/10gen/M202/2014_July/syllabus	2.4273	16/7/2014
10	https://iversity.org/my/courses/web-engineering-iii-quality-assurance/lesson_units	2.9524	16/7/2014
11	https://class.coursera.org/ltto-001/human_grading	3.0698	29/7/2014
12	https://class.coursera.org/clinicalpsych-001	3.4831	29/7/2014
13	https://www.udemy.com/hacking-academy-monitoring-transmitted-data/#/	3.5704	13/7/2014
14	https://class.coursera.org/ltto-001/wiki/module5	3.8103	29/7/2014
15	https://class.coursera.org/ltto-001/wiki/module3	3.9054	29/7/2014
16	https://class.coursera.org/ltto-001	3.9133	29/7/2014
17	https://www.udemy.com/from-ccna-to-ccie-part-1-ccna-labs/#/	4.2361	13/7/2014
18	https://class.coursera.org/clinicalpsych-001/wiki/week_1_page	4.2650	29/7/2014
19	https://courses.edx.org/courses/HarvardX/CS50x/2014_T1/a7ec0c0a7b6e460f877da0734811c4cd/	4.4575	29/7/2014
20	https://class.coursera.org/crypto-011	4.5465	13/7/2014
21	http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-00sc-introduction-to-computer-science-and-programming-spring-2011/index.htm	5.4530	16/7/2014
22	https://class.coursera.org/devdataprod-003	6.0040	13/7/2014
23	https://iversity.org/courses/the-do-school-start-up-lab	6.5789	16/7/2014
24	https://class.coursera.org/crypto-011/quiz?quiz_type=homework	7.5926	29/7/2014
25	https://class.coursera.org/ltto-001/wiki/Class_Resources	8.2553	29/7/2014
26	https://class.stanford.edu/courses/Engineering/CS101/Summer2014/info	2.2215	16/7/2014
27	http://www.saylor.org/courses/cs305/	10.0 **	13/7/2014
28	http://www.saylor.org/courses/ma304/	10.0 **	13/7/2014
29	https://courses.edx.org/courses/HKUSTx/COMP102x/2T2014/info	10.0 **	13/7/2014
30	https://learn.open2study.com/mod/firstlook/view.php?id=40106	10.0 **	16/7/2014
31	https://learn.open2study.com/mod/firstlook/view.php?id=39112	10.0 **	16/7/2014
32	https://class.coursera.org/crypto-011/lecture	10.0 **	29/7/2014
33	https://class.coursera.org/ltto-001/lecture	10.0 **	29/7/2014

*P.ID : Refers to website identification number. This number would be used to identify the websites in the experiments that would be run for this research

Table 3: Results of Users in Time Completion Task

COGNITIVE GROUP BY HFT	USER CODE
FD	VC-1
FI	VC-2
FI	VC-3
FI	VC-4
FN	VC-5
FI	VC-6
FN	VC-7
FI	VC-8
FD	VC-9
FI	VC-10
FD	VC-11
FI	VC-12
FN	VC-13
FD	VC-14
FD	VC-15
FD	VC-16
FI	VC-17
FN	VC-18
FD	VC-19
FD	VC-20

Table 4: Extended comparison table

P.ID	Website Name	Complexity Level	Complexity Score ViCRAM	Average Time From Time Completion	Ranking from User Questionnaire
6	UDACITY	Simple	2.0670	36.7 seconds	5.8
21	MIT	Medium	5.4530	61.95 seconds	9.8
23	IVERSITY	Medium	6,5789	36.9 seconds	5.1
24	COURSERA	Medium	7.5926	43.4 seconds	7.8
29	EDX	Hard	10.0	23.75 seconds	8.3
27	SAYLOR	Hard	10.0	34.1 seconds	6.9

Task Completion Test:

Task Completion

The following experiment is part of bigger research project that investigates the visual complexity of websites. The username password for logging in to all sites will be:

Username: chrv.tello@gmail.com
Password: **Vicram_1**

Part 1

Website: Iversity	
Tasks	**Completed**
Find Chapter 5	
Find Course Info	
Find Forum	

Part 2

Website: Saylor	
Tasks	**Completed**
Find Final Exam	
Find Course Requirements	
Find User Assessments	

Part 3

Website: Coursera	
Tasks	**Completed**
Find Module 3 Resource	
Find suggest a Resource	
Find My assignments	

Part 4

Website: Udacity	
Tasks	**Completed**
Find Discussiom Forum	
Find Downloadables	
Find Course Catalog	

Part 5

Website:EdX	
Tasks	**Completed**
Find Syllabus	
Find Discussion Forum	
Find FAQ	

Part 6

Website: MIT	
Tasks	**Completed**
Find Newsletter	
Find Download Course Material	
Find Cite this course	

The process of time completion task has been developed based on how similar studies approach the process. However because the methodology is not included as step by step quite in any of the previous studies, it can be claimed that the development of the questions comes from empirical experience, the main criteria are the following:

1. The question should be of similar difficulty for each of the websites regardless their visual complexity.

2. The questions should not try to find items within the textual context but rather links or buttons.

3. The objects that users are searching for should not be image's or hidden within tabular menu's or dropdowns, also the objects should be found within the webpage the instructor provides and the users should not need to move to another page to find the object.

In terms of sensitivity of the results based on the selection of objects within the webpage the study recognize that the results are sensible since different objects can produce different times in Time Completion Task. However the basic rules that have been demonstrated above create a common structure for the selection of objects which is one way for validating the results.

Table: Time Completion Task Scores in Second

User Code	Iversity	Saylor	Coursera	Udacity	Edx	MIT	Total
VC-01	33	30	35	24	28	52	202
VC-02	34	24	25	38	21	76	218
VC-03	16	20	37	18	14	78	183
VC-04	33	33	41	27	29	35	198
VC-05	22	30	43	28	18	52	193
VC-06	57	41	46	38	16	55	253
VC-07	24	35	44	21	17	81	222
VC-08	37	35	45	22	17	73	229
VC-09	59	29	60	50	28	79	305
VC-10	30	24	44	19	19	64	200
VC-11	29	32	43	25	29	63	221
VC-12	45	35	44	48	28	50	250
VC-13	32	30	52	65	17	43	239
VC-14	42	60	45	33	28	62	270
VC-15	34	41	41	38	32	85	271
VC-16	42	51	37	32	21	53	236
VC-17	26	27	39	42	23	44	201
VC-18	59	34	50	67	24	81	315
VC-19	39	33	53	52	31	56	264
VC-20	45	38	44	47	35	57	266

Statistical Analysis

SUMMARY OF SIMPLE COMPLEXITY WEBSITES

Groups	*Count*	*Sum*	*Average*	*Variance*		
FD	8	301	37,625	120,8393		
FI	8	252	31,5	130,8571		
FN	4	181	45,25	582,9167		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	515,575	2	257,7875	1,248321	0,312002	3,591531
Within Groups	3510,625	17	206,5074			
Total	4026,2	19				

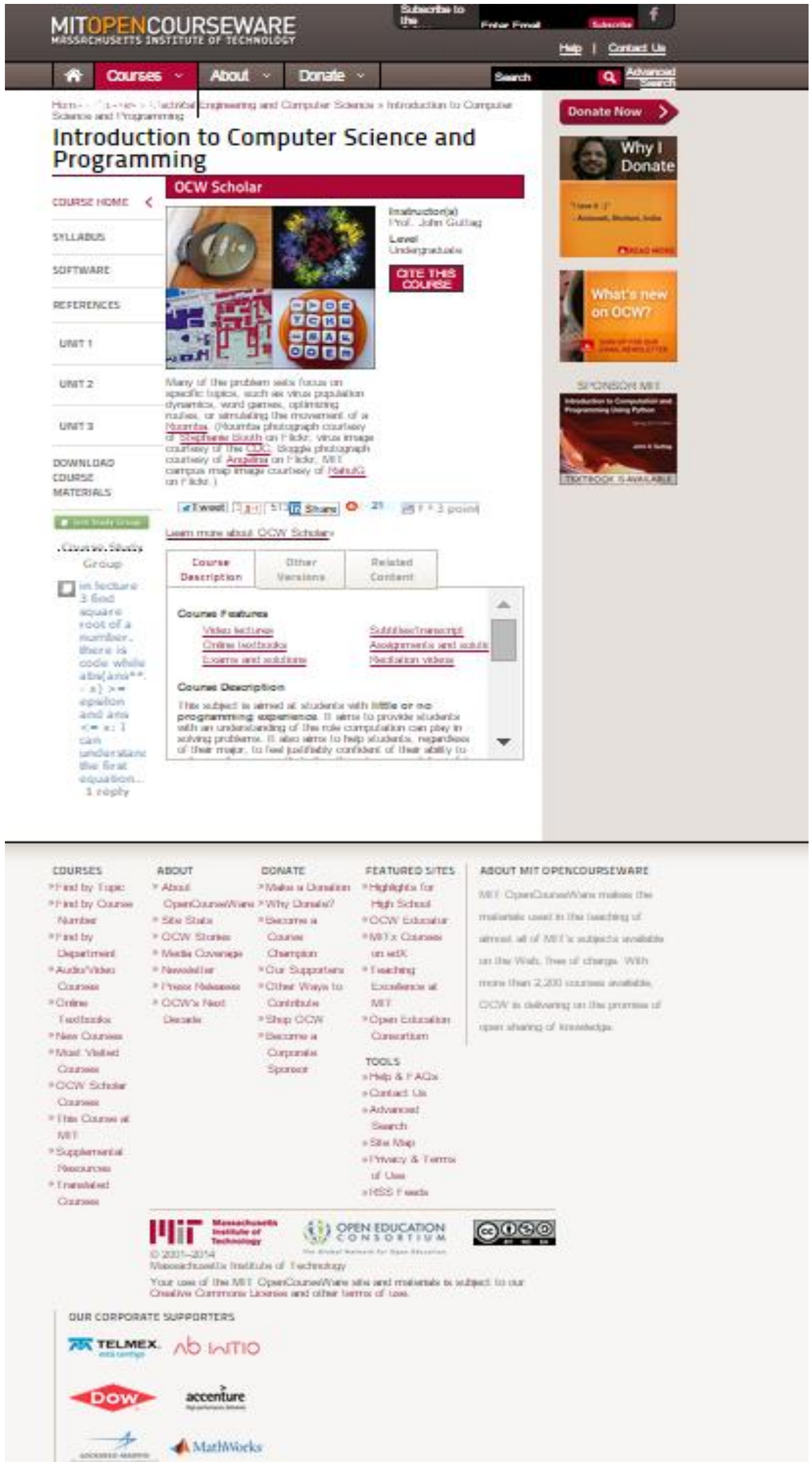
SUMMARY OF MEDIUM COMPLEXITY WEBSITES

Groups	*Count*	*Sum*	*Average*	*Variance*		
FD	24	1188	49,5	195,913		
FI	24	1074	44,75	253,8478		
FN	12	583	48,58333	354,9924		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	291,1667	2	145,5833	0,582357	0,561869	3,158843
Within Groups	14249,42	57	249,9898			
Total	14540,58	59				

SUMMARY OF HARD COMPLEXITY WEBSITES

Groups	*Count*	*Sum*	*Average*	*Variance*		
FD	24	1188	49,5	195,913		
FI	24	1074	44,75	253,8478		
FN	12	583	48,58333	354,9924		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	291,1667	2	145,5833	0,582357	0,561869	3,158843
Within Groups	14249,42	57	249,9898			
Total	14540,58	59				

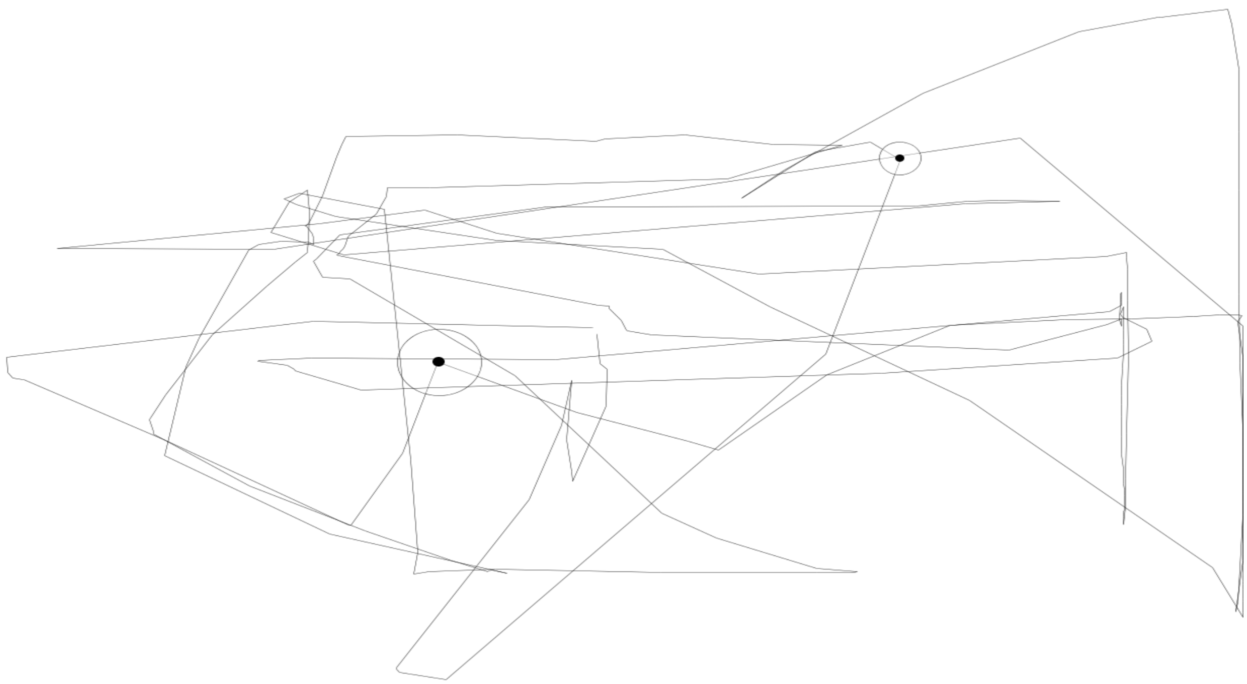
Screenshot MIT.



Samples of User Tracking

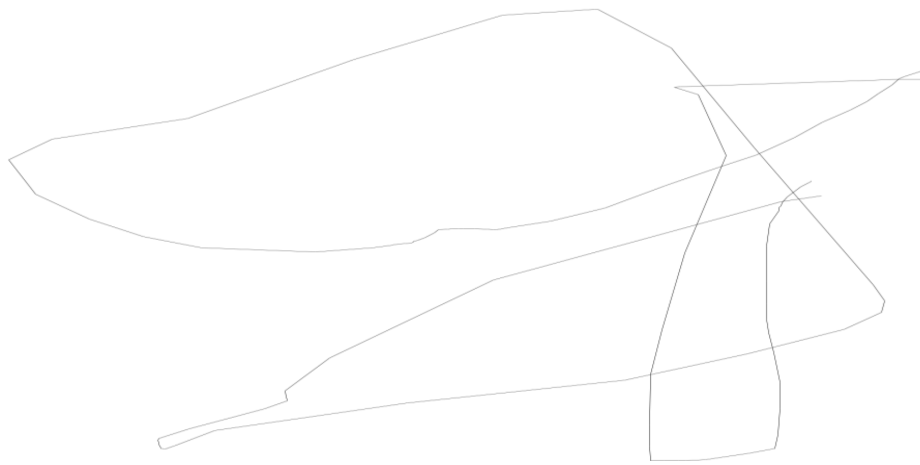
User VC-12, User Classification: FI, Website: Coursera, Task: 2, Time: 25 seconds

Screen Shot 1



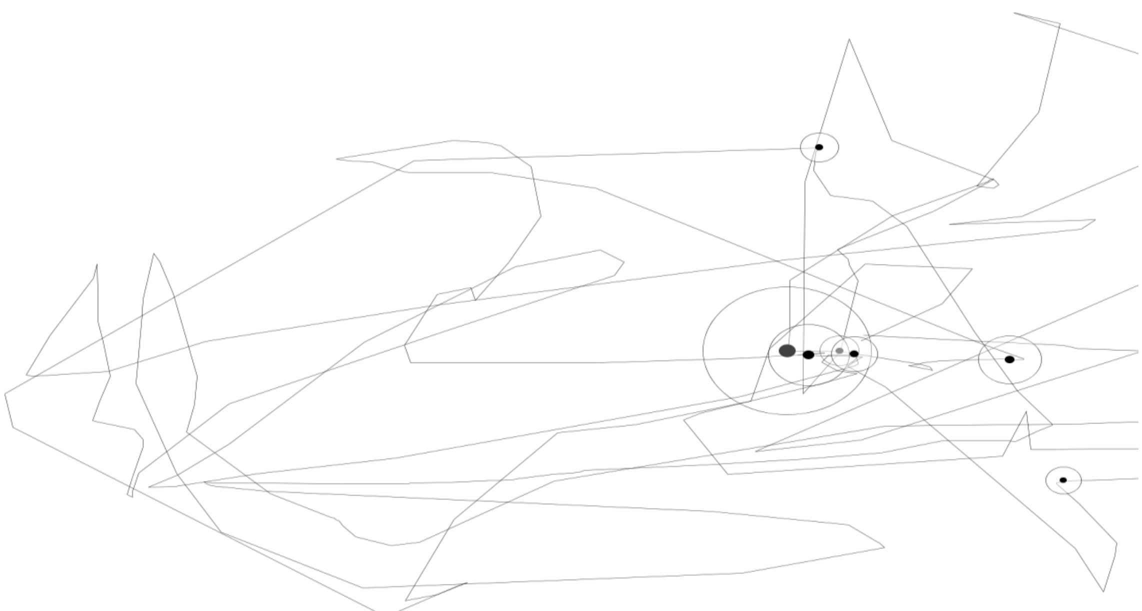
User VC-3, User Classification: FI, Website: Coursera, Task: 2 Time: 7 seconds

Screen Shot 2



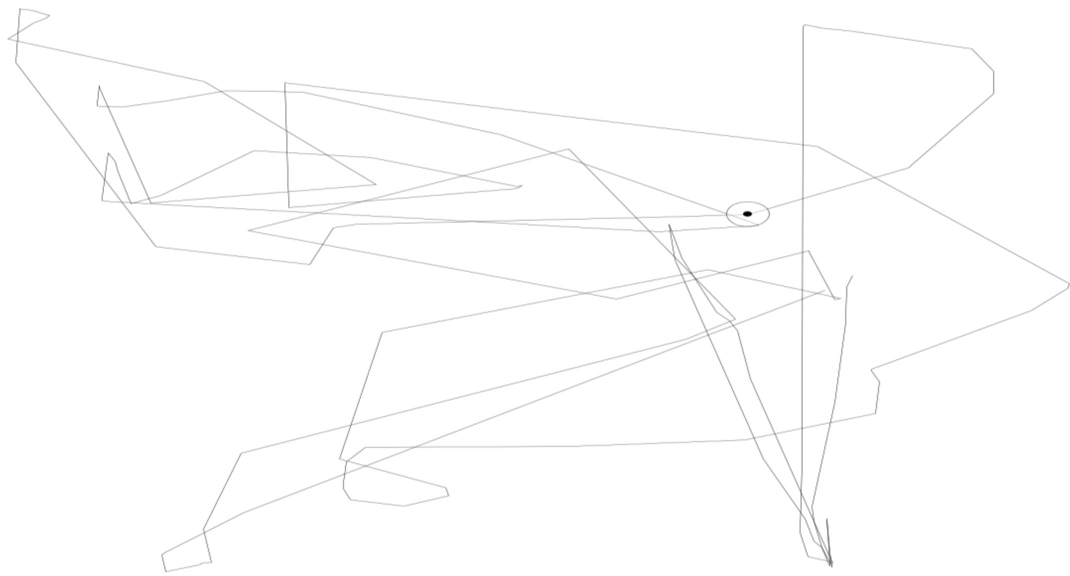
User VC-9, User Classification: FD, Website: Coursera, Task: 2 Time: 40 seconds

Screen Shot 3



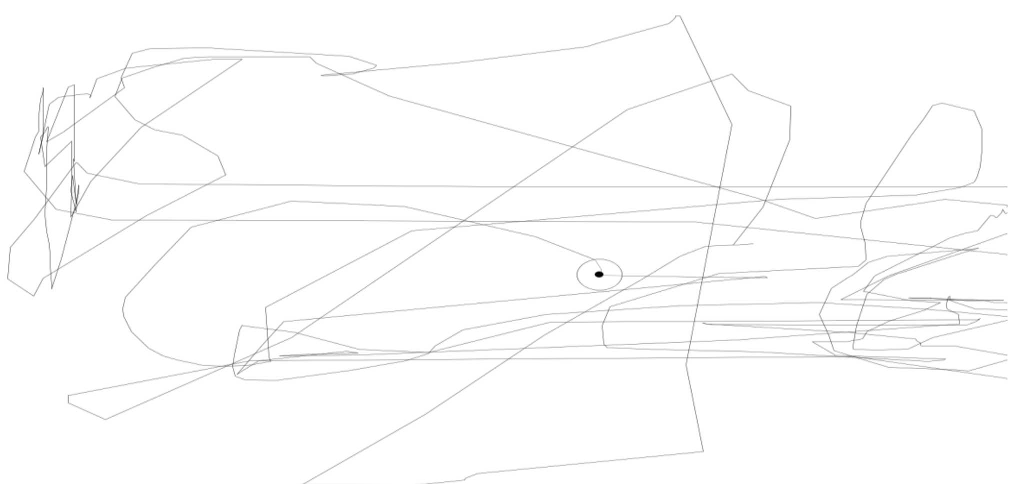
User VC-2, User Classification: FI, Website: Udacity, Task: 3 Time: 24 seconds

Screen Shot 4



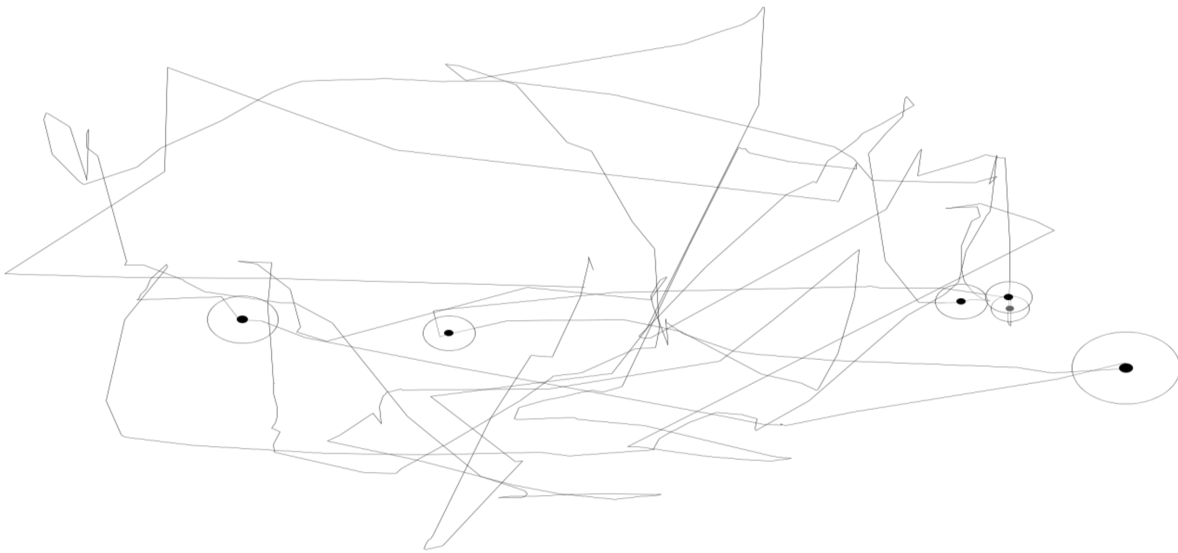
User VC-9, User Classification: FD, Website: Udacity, Task: 3 Time: 33 seconds

Screen Shot 5



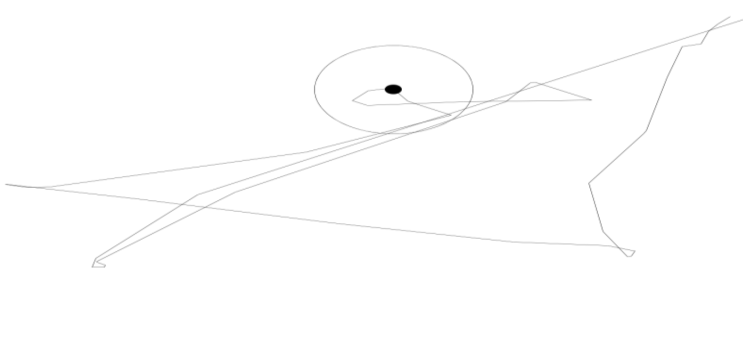
User VC-12, User Classification: FI, Website: Udacity, Task: 3 Time: 41 seconds

Screen Shot 6



User VC-13, User Classification: FN, Website: Saylor, Task: 3 Time: 19 seconds

Screen Shot 7



User VC-13, User Classification: FN, Website: Udacity, Task: 3 Time: 21 seconds

Screen Shot 8

User VC-13, User Classification: FN, Website: MIT, Task: 1 Time: 26 seconds

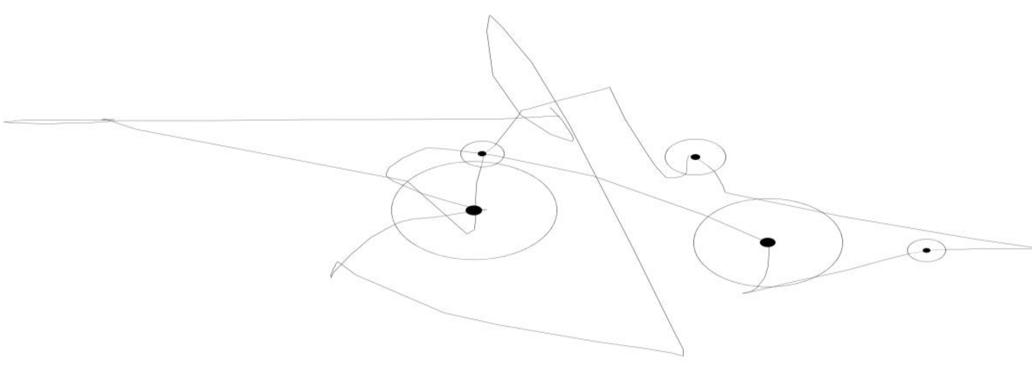
Screen Shot 9

User VC-3, User Classification: FI, Website: MIT, Task: 1 Time: 25 seconds

Screen Shot 10

User VC-11, User Classification: FD, Website: MIT, Task: 1 Time: 42 seconds

Screen Shot 11



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