Modelling Adaptive Hypermedia Instructional Systems

Abstract

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Abstract

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Computer-based instructions are tailored according to learner abilities, interests and needs. In educational technology tailoring instructions according learner needs is termed as adaptive instructions. With the newest form of education technology hypermedia has become popular. Hypermedia is based on linkages that exists among information, this information may exists in different combination of media formats such as text, graphics, pictures, audio, video or animation. Adaptive Hypermedia Instructional System delivers instructions tailored to learner needs.

With the advancement of research in educational technology focus is on generating instructions based on learning theories. Learning theory and hypermedia based instructions are able to achieve effective leaning outcome. Effectiveness of Instructions is also determined by Typography, Color Psychology, and Graphic Aesthetic termed as Ergonomics. Interactive instructions rich in Media, Ergonomics and Hypermedia are engaging and are able to achieve effective learning outcome (Hartely, 1996;Altaboli & Lin, 2011;Jeong, 2016).

Media consists of text, images, graphics, audio, video or animation or combination of these. Media has substantial influence on retention power. Research findings subsist that supports the effectiveness of words and pictures, avoiding irrelevant media, using narration in place of text and proximal position of words and pictures (Mayer, 2005). It was established that learner understanding for words and pictures is found to be much better than words alone (Mayer & Gallini, 1990) and they can build knowledge using videos or animations (Chambel, Zahn, & Finke, 2006). Thus, use of media components - text, images, graphics, audio or animation or combination of these must be based on rules capable of achieving effective and efficient learning outcome. Learning outcome also depends on location of media components on the learning interface. Design of learning interface is determined by Ergonomics.

Ergonomics of learning interface is determined by Graphic Aesthetic, Typography and Color. Every learning interface must maintain graphic aesthetic principles such as Repetition, Alignment and Proximity. These principles increase readability and understandability. Repetition, Alignment and Proximity determine placement of media elements on learning interface. Pertinent location of these elements gain learner attention and improves degree of learner engagement. Thus, determining most suitable graphic aesthetic principles to gain learner attention and in-turn achieving positive learning gain is still a subject to study. Learner attention is also affected by typography. Good typography enhances readability and avoids distraction. Most of the instructional material consists of text. Typeface and font-size of displayed text determines the level of readability. Adequate spacing between letters, lines and paragraphs is also a determining factor of legibility, and in-turn improves

level of readability. Thus, finding most suitable typeface, font-size, adequate spacing between letters, lines and paragraphs is a subject to study. Color of typeface is also a critical factor that needs to be considered to avoid distraction.

Color combination, luminance contrast and color difference has noticeable impact on legibility of text (Humar, Gradisar, & Turk, 2008). Meaningful use of color act as a visual cue to improve readability (Richardson, Drexler, & Delparte, 2014). Color has psychological affects that can aid in attaining learning gains (Fehrman & Fehrman, 2000). To opt for a precise color scheme color wheel may be used. Color scheme, varying in contrast, is used to differentiate components on learning interface. Feedback component is usually presented using bright colors to catch learner attention. Different color provides different feedback. Thus, to gain learner attention, to differentiate between different components on learning interface, to enhance readability and to provide effective feedback suitable color scheme must be used. Hence, there is a need to conduct investigative study that can be used along with micro-research findings on appropriate utilization of color. Colors aids in navigating to learning resources and avoiding the problem of disorientation.

Learners navigate to learning resources to find relevant information. Good navigation system improves quality of learning (Shahzad, Hafizi, & Golamdin, 2014). Well-structured navigation system avoids distraction and instead of getting disoriented learner move forwards in the direction of achieving learning objectives (Ahmadi, 2016). Selection of navigation structure depends on prior knowledge, cognition and self-efficacy of learner (Macgregor, 1999). Other factors that determine navigation structures include screen layout and consistency to be achieved on other screens (William & Francis, 1998). Thus, it becomes requirement of undertaken research to find navigation structures that can produce effective and efficient learning outcome taking Graphic Aesthetics into consideration.

Graphic aesthetics provides visual cues. Visual cues increase learning gains. Graphic aesthetic is determined by colors, fonts and location of media components and navigation structures. Principles of graphic aesthetics must be followed to design learner engaging learning interface. Few of the most common graphic aesthetics principles include Alignment, Balance, Proximity, Style, Repetition etc. Thus, choosing most appropriate graphic aesthetic principle to accomplish successful learning is one of the research objectives.

A comprehensive review of literature revealed a pertinent research gap to develop framework having minimum but sufficient constituent of Media, Ergonomics and Navigation Structures capable of generating efficient and effective instruction. This framework based on instructional sciences is referred to as ‘Modelling Adaptive Hypermedia Instructional Systems (AHIS)’. AHIS must include the following features:

- Appropriate media selection and presentation expressed as Media Worthy Component.

- Learning interface, determined by principles of graphic aesthetic, typography and color that are Ergonomics of learning interface must be maintained.
- Using suitable navigational structures to support hypermedia.

The proposed framework must have sound theoretical footings to incorporate above stated features. Literature survey was conducted on most common and reliable citation databases in the domain of Computer Science and Information Technology. Few of the prominent databases include Wiley, IEEE Explore, Springer, Science Direct, Scopus and ACM Digital Library. Keywords used for searching database included "Instructional Model", "Multimedia", "Navigation Structures", "Typography", "Color Psychology", "Graphic Aesthetic", etc. The search was conducted on abstract, keywords and on title. Search ended-up with peer-reviewed journals, conference proceedings, technical reports and books on instructional media, color psychology, user interface design etc., being evolutionary in nature research article taken under study kept on growing.

There has been horizontal and vertical growth in the domain of instructional design. Instructional model has evolved over the years to facilitate learners to achieve their respective goals. Selecting most appropriate instructional model to deliver instruction is a tough task. To accomplish this meaningful comparison among models was carried out. Hence, a comparison of existing instructional design models was undertaken using the Gropper (1973) list considering it as benchmark to review models. Comparison revealed Component Display Theory (CDT) as one of the most suitable theory on which framework can be developed (Merrill, 1983). Component Display Theory specifies Primary Presentation Forms (PPF) and Secondary Presentation Forms (SPF) to achieve learner engaging exercises. Theory generates instructions having necessary primary and secondary forms. Analytical study on CDT drew-out following improvements or modifications that can be made to CDT (Antwi, 2017; Glazatov, 2015):

- Presenting learning content in multiple forms i.e., what is the most appropriate media worthy component to generate instructions?
- What are the parameters that can be included in CDT to grab learner attention?
- Instructional material to be presented must be in a sequence. What are the technological parameters that can be utilized to maintain a sequence?

Component display theory utilizes text/graphic to provide interactivity, but it does not provide particular combination of media to promote learning. Theory does not provide proximal location of words and pictures that has direct effect on comprehension; theory does not give any evidence about the use of animation or narration or its effectiveness or detrimental effect on learning.

Component Display Theory does not provide guidelines on interface designing principles. Interface Designing Principles adds value and meaning to interface. These principles simplify and add clarity to learning content. Interface augment interactivity, improving rate of learner engagement. Learner engagement is precious. Degree of engagement is increased by gaining learner attention. In

Component Display Theory no traces have been found of gaining learner attention through principles of interface design.

Learners are most comfortable in learning when they have adequate control of their learning environment. They explore through learning content to trace relevant information. Exploration is done through navigation structures. Component Display Theory has no work on navigation structures. However, it was observed that Component Display Theory has following Components *first*, Learning Content Categorization and *second*, Instructional Strategies.

If Component Display Theory is extended by including Media Worthy Component, Ergonomics (Interface Designing Principles) and Navigation Structures then it may produce more learner engaging instructions. A framework was developed based on Component Display Theory. This framework was analysed by experts in the field of Education Technology and Computer Science. Based on expert comments framework was improved and again evaluated by experts of instructional sciences. Finally, a prototype was developed using framework guidelines. Effectiveness of developed prototype was evaluated by set of graduate and undergraduate learners of computer science. Participants were subjected to experiment with prototype against test application.

Pre-test consisting of five problem solving questions was used to assess learner knowledge level. Learners were given brief description about the developed prototype. They were given instructions about evaluation criterion to be followed before assessing prototype. Learning module consisted of four lessons – 'Introduction to Data Structures', 'Basic Concepts of Arrays', 'Linked list' and 'Application of Linked List'. Participants evaluated prototype against test application. Test application was also developed on Data Structures and lesson topic was similar to that of prototype. Participant evaluation was recorded through survey questionnaire, to measure the effectiveness of the framework on the five point likert scale.

Participants evaluated prototype against test application and filled-up survey questionnaire. Response to survey questionnaire was used for data analysis. Data analysis consisted of analysis of variance. Mean and standard deviation was calculated for each parameter of study. *t*-test was carried out to examine the effectiveness of the framework. Finally *f*-test was carried out to analyse influence of Media, Ergonomics and Navigation Structures on Cognitive, Affective and Psychomotor domain.

Data analysis revealed effectiveness of framework. Overall performance of developed prototype was rated as positive. Results of statistical analyses established that instructions generated using framework guidelines were more learner engaging and were able to produce effective learning outcome. Response to questionnaire was positive, it was established that (90% of the learners accepted) generated instructions act as aid to achieve learning objectives. Learners accepted that using typography on the guidelines of framework improved readability. Domain experts praised presentation of the instructional material they said – "*Graphic Aesthetic, Typography and Color produced eye soothing effect*". Learners admitted that adequate labelling of navigation structures

avoided the problem of disorientation. When instructions were presented using animation with text or illustrations following text script promising results were obtained, as learners found them engaging. Result of *f*-test uncovered the influence of Media and Ergonomics on Affective Domain. As a result it was concluded that AHIS framework is able to generate learner engaging instructions and able to achieve positive learning gains. It is expected that AHIS framework will evolve over time and will move in the direction leading to the development of shell ending up into an Authoring Tool.