Abstract: Learning style refers to learners favored approaches to learn. It assumes a vital part in adaptive educational frameworks. With the information on various styles, the framework can offer significant guidance and guidelines to learners and educators to contribute to learner’s learning process. There exist more than seventy learning style models based on different in view of the different characteristics of learning and cognitive behavior/styles of learner. The present study is organized into two principal parts. First, the study, with an aim to critically examine five learning style models, conclude instruments chosen for identification of learning style, grading influence of learning style on adaptive tutoring, on a scale ranging from least influential to most. Second, in this part it addresses, three fundamental questions, first, the key aspect and implementation of the most influential models for adaptability in a personalized learning environment/tutoring system, second, the implication of these models on teaching and third, the future prospects, envisioned thereof.

Keywords: Learning styles, adaptive intelligent tutoring system, Adaptability, learner characteristics, cognitive model, and meta-cognitive skill.

1. Introduction

Throughout the years, several studies have demonstrated escalated advance in providing the education through e-learning mode. This is due to quick progression in the computer technology and web development. Numerous e-learning frameworks have been created to provide learning in light of learner preferences and individual traits. E-learning mode of education not just offers customized learning environments; but also can be utilized for tutoring heterogeneous gathering of learners [1]. Different learners have their own distinct knowledge levels, learning objectives perceptions about the subject area, learning styles, and characteristics [2, 3]. To oblige learner, most educational institutions offer e-learning framework, that empowers learner to download learning material and take part in interactive sessions, for example, live courses and discussions. Most e-learning frameworks provide comparable e-learning tools to course planners, for example, wiki, glossary devices and learner profile highlights.

The learning material, conveyed by e-learning framework to the learner assumes that each learner learns in same manner utilizing common learning material and advances towards achieving lesson objectives along with their associates. E-Learning frameworks are constrained in terms of providing personalization to their learners and consider a “fits for all types” mindset. The fundamental issue is that learners have distinct background, knowledge level, learning skills, motivation and subsequently, every learner has diverse necessities and way of learning. Numerous learners encounter disappointment with such type of frameworks and get exhausted as they progress through their learning cycle since the material is static, and not sensitive to the need of the learner [4]. A conceivable cure is the Adaptive Educational System (AES) which negates the learning management system approach of “fits for all types”.

There has been clear enhancement in learner’s accomplishment levels where learners are instructed in view of their analyzed learning styles in face to face teaching. According to many psychologists and educationalist, which contend that students have distinctive routes in which they like to learn. Besides, Felder-Silverman (1988), brought up that students with a solid inclination for a particular learning style may experience issues in learning if the teaching style does not coordinate with their learning style. So concluding from the theoretical prospective, fusing student learning style in tutoring system makes learning easier, adaptive, understandable, and productive.

There are different types of learning style models exists, that is utilized by the pedagogy expert and psychologists to provide the adaptivity in learning
Because of the success of different learning style models in recognizing how a learner learns, educationalists have attempted to consolidate these models to adaptive learning system. Kolb and Felder have utilized their learning style model successfully for engineering discipline, while Honey and Mumford model has been utilized as a part of business and administration training [8]. To further improve its adequacy, and perspectives, learner modeling is likewise considered. For instance, the student’s individual profiles, for example, sex, age group, knowledge level and progress made during learning are consolidated into adaptive educational systems.

In this paper, the study has been classified in two parts; first, critically examining the five most influential learning style models from over seventy existing learning style models grading their influence from highest to least. Second part presents the comparative summary of five learning style models, and their implication on teaching highlighting their strength and weaknesses.

2. Related Work

A. Learning Styles

The learning styles field is mind boggling and influenced by different psychological dimensions, prompting diverse ideas and perspectives. Till now, there is no unique definition of learner style is identified. For examples, learning style is characterized as the attributes, qualities, and preference in which individuals gather, memorize and execute the information [9]. According to James (1995), learning style is a complex characteristics of student in which they effectively and precisely take, store and process the information what they want to learn.

It recommends that each individual has distinct particular style or set of strategies employed while learning. Many explores have since quite a while ago attempted to relate with the personality traits of learners to the education, and the learning style. It can likewise be characterized as the way a learner gathers, processes and comprehends the information. Along these, the learning style gives instructors, an outline to the need and inclinations of the individual student.

There exist several learning styles models, each offer diverse depictions and characterizations with the types learning. Individuals have different learning styles and these individual differences turn out to be much more important to provide the personalized learning. Honey and Mumford [18] characterized learning style as being 'a depiction of the states of mind and conduct which decide a given learner’s favored approach to learning'. A few reviews report that learners learn in varied ways, based on personal learning attributes/characteristics and everybody has a distinct style of learning [19, 20]. These investigations demonstrate likewise that relevant learning style of learners with the learning material is a principal aspect that affects learning result. Various examinations demonstrate that the learner’s performance will be improved if the teaching material is aligned to the learning style of learner.

There are several reviews that demonstrate the utilization of an adaptive education hypermedia in view of learning style in instructing or learning particularly for the higher educational level[10, 11]. Liegle and Janicki [15] directed an experimental test for a gathering of sixty-eight college students, who were selected in the Principle of Management subject [12]. They utilized Kolb model of learning to quantify learning style preferences of learners. The learners' navigational conduct was always observed and logged. Learning styles of learner are considered as one of the most significant variables impacting learner accomplishment. So the learning style is one of main subject of studies by analysts and instructive researchers [13] since 1940s.

Cofield et al. [14] distinguished over seventy models of learning style. Moreover, a ton of research has been conducted in most recent 30 years. Hence, when a tutor's tutoring style matches with learning style of a learner's; this influences the learner’s understanding and enhances learning capacity of learner. Until today, huge research has been reported about the learner’s learning styles and developed a decent arrangement of learning style models however there does not appear to be any understanding of acknowledgment of any one hypothesis [21]. There have been several models for characterizing and measuring learning styles, proposed, for example, Kolb's survey [22], Honey and Mumford's poll [20], Keefe's survey [23], The MBTI poll [24], Felder and Solman [25, 26] proposed a psychometric poll ILS questionnaire. In this way, in our review, we embraced the Felder Learning style model demonstrates as one of the notable source data for personalization. Among all, the most utilized learning styles are, Felder model, Kolb model, MBTI, Honey-Mumford, and VARK stand out.

3. Learning Style Model Classification

For the purpose of the detailed study of the learning style models, we categorize them into the four major classes

1. Fixed personality type
2. Cognitive structure/behavior
3. Constitutionally-based learning styles and inclinations
4. Dynamic identity sort
Table 1. Summary of classification of learning style models based on learner characteristics

<table>
<thead>
<tr>
<th>Classes</th>
<th>Learning style models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable personality type</td>
<td>Apter MSP model, Epstein and Meier, VARK Model, Harrison-Branson model, Miller, and Jackson, Myers-Briggs Types Indicator (MBTI).</td>
</tr>
<tr>
<td>Constitutionally-based learning styles and inclinations</td>
<td>Dunn and Dunn Model, Gregorc Thinking Style, Bartlett sensory preference model, Betts Inventory, Gordon Imagery scale, Marks Questionnaire, Paivio IDQ, Richardson VV Questionnaire, Sheehan Inventory, Torrance Thinking and Learning style</td>
</tr>
<tr>
<td>Dynamic identity sort</td>
<td>KAI Inventory of Kirton, LSQ of Honey and Mumford, Felder and Silverman Index of LS, QPL test of Hermanssen et al., HBDI Learning Style Model of Herrmann, Kolb Learning Model, A-E Inventory of Kaufmann, 4MAT Model of McCarthy, Cognitive Style Index (CSI) of Allinson et al., Wierstra Model</td>
</tr>
</tbody>
</table>

Inside every class, we assess in detail most five influential models highlighted in bold in above LS models classification table (Table-1), looking both at thinks about where analysts have assessed the basic hypothesis of a model keeping in mind the end goal to refine it and experimental examinations of unwavering quality, legitimacy and educational effect.

3.1 Learning Style Models

In adaptive learning framework, various learning styles theories have been used. In this section, we focused on five most influential learning style models/theories, comparative summary, and their implication on teaching are described.

3.1.1 Felder-Silverman Learning Style Model (FSLSM)

FSLSM portrays every learner under four measurements and accordingly empowers adaptive tutoring system to offer learning material that best fits learner’s preferences (Graf et al. 2009). Also, learners, whose conduct are distinctive for a specific assignment or have diverse work propensities, empowering the learning style model to consider rare conduct. One more essential motive behind Felder model was that it is for the most part utilized as a part of adaptive educational system concentrating on learning styles of learner, which subsequently commit this research generally appropriate.

Felder describes learning style of learner as per four measurements: sensory/intuitive, active/reflective, visualizer/verbalizer, and sequential/global.

Figure 1. Felder-Silverman learning dimensions

The sensory learners like to learn with certain or factual learning material. They have a tendency to prove and study evidentially rather than intuitive learners and prefer relating learning material to its present real-time application. Intuitive learners concentrate on dynamic idea, for example, hypotheses and their implications. They are more imaginative and inventive and prefer the chance to find conceivable outcomes and associations with new thought. Consequently, they tend to achieve better in open-finished tests and issues.

The active learners are more dynamic with their learning material and learn by doing. Besides, they have a tendency to learn by working in groups and are more inspired by correspondence with others. Reflective learners learn by thinking and reflecting about the things. They have a tendency to work alone do not get excited about learning by corresponding with others.

The visual learners recollect or recall best what they have seen, for example, illustrations, graphs, photo and stream diagrams. These learners prefer mapping learning idea to outwardly key focuses e.g. shading coding notes. Verbal learners gather more from words and talk clarifications of illustrations and graphs, listening to his/her classmates or writing outlines.

In the last measurement, the students are described by their comprehension. Sequential learners learn in
straight strides and with consistent little incremental strides for discovering arrangements. Conversely, global learners are based on holistic thinking and bounce to expansive stride. They are inclined toward irregular learning material, and in the process, discover novel way to solve complex issues.

3.1.2 Kolb’s Learning Style Model

This model on Kolb's experiential learning idea, characterized by the two-dimensional scale in light of how a learner perceives and process the information. Concrete Experimentation (CE) or Abstract Concept (AC) dimensions defines that, how student perceive the information in learning conditions and how individual processed data was delegated Active Experimented (AE) student or Reflective Observed (RO) learner (Simpson and Du, 2004).

3.1.3 VARK Learning style model

VARK learning style model depends on VARK survey that recommends the tutoring systems in light of his/her learning styles, and table 2 demonstrates the VARK four learning style measurements (Visual, Auditory, Read/Write and Kinesthetic). As indicated by Fleming’s genuine suggestions for suitable mentoring methodologies are presented in table 2 along with corresponding learning object.

Table 2. Summary of VARK learning style dimensions with corresponding tutoring strategies and LO

<table>
<thead>
<tr>
<th>VARK learning style dimensions</th>
<th>Tutoring strategies recommended by Flemings</th>
<th>Corresponding Learning object (LO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>Pictures/diagrams, charts, video, posters, slides, graphs, mind maps, diagrams</td>
<td>Video, and Power points slides.</td>
</tr>
<tr>
<td>Auditory</td>
<td>Topic discussion, talking through thoughts, remember stories, recorded notes</td>
<td>Power Points slides with audio, recorded notes.</td>
</tr>
<tr>
<td>Read/Write</td>
<td>Lists, headings, written notes, definitions, text manuals</td>
<td>Power Points Slides Text documents.</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>Interested in doing, practice tests, experimental approach</td>
<td>Hands on exercise, case studies.</td>
</tr>
</tbody>
</table>

VARK learning style model depends on the way that this learning style contrasts with others and could
likewise be unmistakably matched the type of tutoring material.

### 3.1.4 Honey and Mumford Learning Style Model

According to Honey and Mumford (1986a), there are four distinct styles of learning or preferences that individuals use during the learning. They prescribe that most of learners have a tendency to prefer just a single or two of these styles, and that particular learning activity may accommodate all requirements of particular styles of learning.

According to Honey and Mumford (1992), learning style is a portrayal of the states of mind and conduct which decide learners favored methods for learning. Honey and Mumford (1986b) produced a questionnaire that helps to identify individual’s learning styles. As shown in Figure 3, four dimensions of learning styles are depicted and the accompanying records in Table 3 gives a brief outline of learning characteristics and the key activities of every learning dimension.

![Learning Style Model Diagram]

Figure 3. Honey & Mumford learning style attributes

### Table 3. Summary of Honey and Mumford learning style attribute

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Attributes</th>
<th>Key Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activists</td>
<td>Activist’s learners learn by doing, have an open-minded learning approach. They like diverse task learn from new experience and involve actively on learning contents.</td>
<td>Group discussion, role-play activity, brainstorming quizzes, solving critical problem.</td>
</tr>
<tr>
<td>Reflectors</td>
<td>Reflective students do not involve actively, they learn by intuition and watching the circumstances. Prefer to learn from new experience.</td>
<td>Case studies, time taking learning</td>
</tr>
</tbody>
</table>

3.1.5 The Myers-Briggs Type Indicator (MBTI)

This model was created by Katherine Cook Briggs and her little girl Isabel Briggs Myers in light of Jung's speculations, who studied human personality theory over a year (Bachari, E., Abelwahed, H., & Adnani, M., 2011). The MBTI helps people to analyze their behavior and understand themselves. It defines personality preferences rather than measuring skills and gives equal weight age to all learner preferences. Table 4 display the MBTI learner’s inclination on four learning dimensions.

### Table 4. Summary of MBTI learning style preferences

<table>
<thead>
<tr>
<th>Learning preferences</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introvert (I)</td>
<td>Introvert focused on ideas, concept, versus and abstractions and always energetic. Extroverts are action oriented and prefer to interact with others.</td>
</tr>
<tr>
<td>Extrovert (E)</td>
<td></td>
</tr>
</tbody>
</table>
Sensing (S) versus Intuition (N)
Sensing learners favor how to take data in genuine universes. Intuitive learners search out examples and discover connections among the realities they have assembled.

Thinking (T) versus Feeling (F)
They focus on the how learner react on situation and how a learner deals with the external world. Judging types of learners are conclusive, arranged and self-controlled. These learners concentrated on finishing assignment. Perceptive learners are interested, versatile, and unconstrained. They begin many assignments; need to know everything about each undertaking.

The MBTI learning sort can be consolidated to frame 16 learning style sorts’ regularly meant by four letters. For examples, one learner might be ISTJ (introvert, sensing, thinking, judging) and another might be ISFJ (introvert, sensing, feeling, judging) and so on.

3.2 Comparative summary of most influential learning style models
This section defines the comparative summary of the selected five most influential learning style models. Table 6 shows the learning style’s model name, learning style instruments, key terms, and the publishing year. The implications of learning style models on teaching with their strength and weaknesses are shown in table 7. Figure 4 defines the learning style models usage frequencies employed in the analyzed studies.

Table 6. summarizes study of LS models, LS instruments, key terms, and year of publishing

<table>
<thead>
<tr>
<th>Learning style model</th>
<th>Learning style instrument</th>
<th>Key terms</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felder-Silverman</td>
<td>Index of Learning Styles (ILS)</td>
<td>Active and Reflective, Sensory and intuitive, visualizer/verbalizer, Sequential and global</td>
<td>1996</td>
</tr>
<tr>
<td>Kolb</td>
<td>Learning Style Inventory (LSI)</td>
<td>Accommodating, Diverging, Converging, Assimilating styles</td>
<td>1976</td>
</tr>
<tr>
<td></td>
<td>Revised Inventory</td>
<td></td>
<td>1985</td>
</tr>
<tr>
<td></td>
<td>Learning Style Inventory</td>
<td>Visual/Auditory/Read-Write/Kinesthetic</td>
<td>1999</td>
</tr>
<tr>
<td></td>
<td>VARK Questionnaire</td>
<td>Visual/auditory/reflector/theorist/pragmatist</td>
<td>1982</td>
</tr>
<tr>
<td></td>
<td>Myers-Briggs Types Indicator (MBTI)</td>
<td>Perceive/judge, sense/intuitive, think/feel, extraversion or introversion</td>
<td>1962</td>
</tr>
</tbody>
</table>

Table 7. Summary of implication of LS models on teaching with their strength and weaknesses

<table>
<thead>
<tr>
<th>Learning style models</th>
<th>Implications on teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felder-Silverman Model</td>
<td>It is most appropriate for the hypermedia courses [30]. Mostly learning style models characterize students in few gatherings, while Felder depict the learners learning style in more detail, recognizing inclinations on four measurements.</td>
</tr>
<tr>
<td>Kolb model</td>
<td>When all is said in had done the hypothesis cases to give a system to the outline and administration of all learning encounters. Educators and learners might be invigorated to analyze and refine their hypotheses of learning; through discourse, instructors may turn out to be more compassionate with learner. All learners to end up distinctly able in every</td>
</tr>
</tbody>
</table>

Table 6: Learning Style Models

<table>
<thead>
<tr>
<th>Learning style model</th>
<th>Learning style instrument</th>
<th>Key terms</th>
<th>Year</th>
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<td>1962</td>
</tr>
</tbody>
</table>
Learning style model used in the studies on e-learning systems, based on student learning style published between the years 2001 to 2016 were analyzed. When these studies were classified by considering learning style, it has been observed that Felder Silverman model was the most preferred model of learner style used in the learning theories (n= 33; 46.67%). It was followed by Kolb model (n=14; 19.71), VARK model (n=11; 15.49%), MBTI (n=7; 9.84%) and Honey and Mumford (n=6; 8.45%) learning style model.

### Figure 4. Learning style models employed in analysis of studies

#### 4. Conclusion

Over seventy learning style models based on the different learner characteristics have been critically examined, classified and compared uncovering developments, their implications on pedagogy, trends, research gaps and future prospective. Study reveals that several researchers have used Felder-Silverman learning style model and successfully integrated in educational system for adaptivity. It has been observed that ‘learning style’ of the learner as ‘learner characteristic’, has been widely explored to make the systems increasingly adaptive. Analysis of review reveals that there is a high impact of learning style as learner characteristics on academic accomplishments, learner performance, and higher satisfaction level.

#### 5. Acknowledgements

This work is being carried out at University of Petroleum and Energy Studies with the reference number SR/CSI/140/2013. The authors thankfully acknowledge the funding support received from Cognitive Science Research Initiative, Department of Science and Technology for the project. The Authors thank the management of University of Petroleum and Energy Studies, for supporting the work and granting permission to publish it.

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