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Developing Personalized E-learning Environments for Autistic Students from Learning Styles

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Abstract

Learning style model categorizes the learning styles of an individual in terms of personality, behavior and cognitive abilities. Many researchers have proposed different models in order to accommodate the needs and preferences of individuals to improve performance in learning. Learning style model is used in E-learning environment: 1) to identify how students receive and processes information 2) to provide a more effective learning environment 3) to optimize performance of student. A better model will identify clear and accurate data on learning styles and will provide suitable environments. Autistic students have several learning styles based on the challenges they have and the learning environments. This paper gives an overview of models as well as recommends the model that successfully detects their learning styles according to their challenges and preferences to propose an E-learning environment for autistic students.

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Key Words: Autism, ASD characteristics, E-learning, learning styles, learning style model, learning preferences, classroom learning, personalized E-learning.

1. Introduction

For many years, E-learning has become the most successful learning environment that replaces classroom learning in terms of time, place, pace, content, etc [1]. E-learning is the delivery of learning materials by an electronic device. It is based on distributed online learning, virtual learning, feedbacks etc. The E-learning system, in its earlier stage includes the infrastructure, which allows the creation, storing and accessing of learning contents [2]. The students are allowed to access the delivered contents from the system. The advanced stage of E-learning has happened by making connections or links among learning resources and people. The people are allowed to follow those recommended links [3].

There are a number of applications used to provide a personalized learning in E-learning environment so that a specific learning can be provided to students according to their needs and behavior. The learning style (LS) can be defined as the way a person collects, organizes and process information [4]. Each student has their own needs and preferences by which they can learn effectively according to their learning styles. Learning styles model is a system that categorizes the learning styles of an individual in terms of his personality, behavioral and cognitive abilities. Learning styles model is used in E-learning environment that identifies how students receive and process information according to their needs and capabilities [5].

The paper aims to study different learning style models that could potentially support E-learning for autistic students. Autism is a neurodevelopment disorder which causes developmental delay in an individual and it exists throughout the life. It causes delay in their skill developments which are essential to carry out living tasks and activities in their day to day life [6]. Students with autism face difficulties in social interaction, communication, behavior, cognitive developments, learning styles and logical thinking [7], [8].

As it is known that educating autistic students is challenging since they possess special needs and behaviors. It is estimated that autistic students are more attracted towards visual based medias like pictures, videos, etc. Hence they can be educated more efficiently using visual medias whether through traditional or digital methods [9]. Though they have several challenges they are thus able to learn through the ways the normal students learn.

With digital technologies sweeping our world people tend to follow these technologies. Autistic students are also influenced by these technologies especially for playing and have identified advantages in their learning characteristics [10]. Hence they have the tendency to learn with these interactive technologies like the computer, smart phones, etc. E-learning, a part of digital technology becomes the favorable methods of learning for autistic students without completely replacing the traditional methods [5].

Currently, there are enough E-learning environments and learning styles models for normal students. Such environments will help the students to improve their knowledge and skills in the easiest and effective ways. From many proposed learning styles models, we consider some popular models and to choose a model that will effectively fit with the learning styles of autistic students.

2. Learning Style Models

According to Kemp learning styles are traits that refer to how individuals approach learning tasks and process information [11]. Learning style models are defined as the model that identifies the learning and cognitive styles of individuals. Accommodating learning styles of individuals in E-learning platform has made the shape of personalized E-learning environments. In personalized E-learning environments, every individual learns from different ways according to their needs and behaviors. Through the identification of learning styles, one can detect their needs and preferences of learning and thus help to improve the learning by providing learner specific instructions and tutorials. According to [12], normal students learn from different modes and with different styles given below.

Table I: Learning Modes of Normal Students

Learning Modes	Characteristics
Television	Using TV children can get information by news channels, cartoons, etc.
Classroom teaching	Taking lecture notes, seminars, assignments etc.
Group study	A type of learning where information is shared with others.
Online tools	Online sites like Khan Academy, byju's.com , online videos, audios, animations.
Digitals tools	SMART boards.
Mobile phones	Students can gather information from search engines using mobile phones.
Social media	Students can collect information from various social medias like Facebook, WhatsApp.

Table II: Learning Styles of Normal Students

Learning Styles	Characteristics
Reading	From reading books., journals, etc.
Visual learning	Learning visually from videos, animations, etc.
Hearing/Auditory	Learning by hearing lectures, presentations, etc.
Kinesthetic	Learning by doing some works, making objects, etc.

As the table I and II shows, normal students learn from different modes and they have several learning styles. Learning styles models can apply into E-learning system to identify the learning styles of each student. Based on the model selected, we would get a defined set of learning styles of students.

The table III shows the different models proposed by different researchers and their learning styles.

Table III: Learning Style Models

Models	Dimensions / Learning Styles
Kolb's Learning Style model	Divergers(Concrete-Experience(CE) & Reflective-Observation(RO))
	Assimilators(Abstract-Conceptualization(AC) & Reflective -Observation(RO))
	Converges(Abstract-Conceptualization(AC) & Active -Experiment(AE))
	Accommodators(Concrete-Experience(CE) & Active-Experiment(AE))
Honey and Mumford model	Activist
	Reflector
	Theorist
	Pragmatist
Felder–Silverman model	Active/Reflective
	Sensing/Intuitive
	Visual/Verbal
	Global/Sequential
Myers Briggs model	Introvert/Extrovert
	Sensing/Intuition
	Thinking/Feeling
	Judging/Perceiving
Jacksons model	Sensation seeking
	Goal oriented achievers
	Emotionally intelligent achievers
	Conscientious achievers
	Deep learning achievers
Niles Fleming VARK model	Visual
	Kinesthetic
	Auditory
	Reading
Gregorc's Mind Style model	Concrete-Random
	Concrete-Sequential
	Abstract-Random
	Abstract-Sequential

From table, we first study popular models like the Honey and Mumford, Felder –Silverman, Myers Briggs, Kolb's Learning Style and Niles Fleming VARK model to identify the learning styles of students by taking their individual learning needs and preferences.

Honey and Mumford Model

Honey and Mumford's model was developed to analyze the learning style preferences of management trainees. Honey and Mumford's learning style questionnaire (LSQ) theory has been widely used as an instrument of detecting students' learning style in higher education (Duff & Duffy, 2002) [13]. The LSQ is designed to probe the relative strengths of four different learning styles shown in Fig. 1.
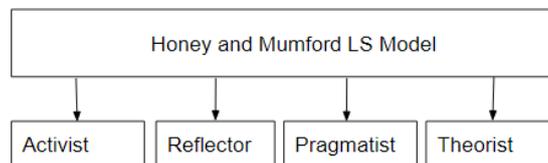

Fig. 1: Honey and Mumford Learning Styles

- Activists: Activist learners love trying right and wrong by themselves. They are impatient and like to explore new concepts and ideas. Also, they are fascinated by showing out activities.

- Reflector: Reflectors learn by observation. They decide and do activities after collecting more information. Though having highly careful sense, they are opposed to being the leader of the group. Also, they are extremely aware of expressing their opinions.
- Theorist: Theorist learners use logical approach when dealing with theories and rules. They analyze and hypothesize everything with the theories.
- Pragmatists: Pragmatists learn tasks by considering their own experience. They pay lot of care and attention to the work being carried out than that of the theories along with the work [13].

Implementation of the Model:

According to Honey and Mumford LSQ (Learning Style Questionnaire) theory, this model uses questionnaire, to find learning styles. The four learning styles are measured using the ordinal scale (1) disagree strongly (2) disagree (3) neutral (4) agree (5) agree strongly [14].

Felder-Silverman Learning Style Model (FSLSM)

FSLSM has been the most popular model which is heavily used in computer-based educational systems [14]. FSLSM supports a classification of student's style in four different dimensions which is more flexible than bipolar models. Based on FSLSM 16 different learning styles are identified between preferences on four dimensions as shown in Fig. 2 [15]. Each dimension distinguishes between two opposite characteristics.
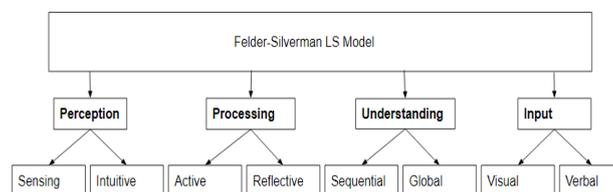

Fig. 2: Felder-Silverman Learning Style Dimensions

- Active/Reflective dimension: Active learners are active/smart, motivated; prefer trial-and-error, and having self-confidence. They like to learn in groups. Reflective learners like to learn independently and think deeply while learning.
- Sensing/Intuitive dimension: Sensing learners like to learn from facts and dislike surprises. They are good at practical works and careful. They like courses that have connection to the real world. Intuitive learners are innovative and dislike doing the same thing repetitively. They prefer discovering possibilities and relationships and tend to be better at grasping new concepts.
- Visual/Verbal dimension: Visual learners learn from pictures, diagrams, flowcharts, timelines, films, demonstrations, etc. Verbal learners learn from written and spoken explanations.

- Sequential/Global dimension: Sequential learners use step by step method to solve a problem with each step following logically from the previous one. Global learners solve problems quickly with less no of steps and tend to learn in large jumps without seeing connections [16].

In this model, learning styles can be derived out from the combination of different sets of learning preferences specified as four dimensions. So sixteen different learning styles are created by the combination of LS in the four dimensions. Each learning style of FSLSM is described by different characteristics [17].

Implementation of the Model:

In Order to determine the learning styles, Felder-Silverman Index Learning Styles (ILS) questionnaire is used. It consists of 44 questions, 11 for each dimension. The scores for each dimension is determined by giving values with odd number from -11 to +11.The answer with positive preference will add +1 to each dimension, otherwise decremented by 1. Thus a positive preference denotes the value for the first part of all the dimensions such as active, sensing, visual and sequential and is denoted as answer a, otherwise answer b.[4].

Kolb's Experimental Learning Model

Kolb's learning model is composed of two dimensions, one for grouping and another for transforming. To Kolb, knowledge came from the blending of perceiving or grouping and transforming experience [Kolb and Kolb, 2005]. For each dimension, there are two poles. The grouping dimension includes Concrete Experience (CE) and Abstract Conceptualization (AC). The transforming dimension includes Reflective Observation (RO) and Active Experimentation (AE) [18].

Kolb classifies the learning Styles into four types based on the above-mentioned dimensions as shown in Fig. 3[26].
- Diverging (CE-RO): Diverging learners respond more to explanations of how course material relates to their experience, interests, and future careers.
- Assimilating (AC-RO): Assimilators will have more tendencies to learn knowledge presented in an organized and logical fashion.
- Converging (AC-AE): Converging learners are active and prefer trial and error in their works.
- Accommodating (CE-AE): This learners like to apply course materials (what they have studied) in a new situation to solve real problems [19].

Implementation of the Model:

In Kolb's model, learning styles of students are measured by using Kolb's learning style inventory (LSI). It consists of 12 questions. Each question has four answers. The student has to rank the answers scaling from 1 to 4 according

to their preferences. The answers are organized into 2 bipolar dimensions described above. The numbers are summed to give scores for CE, AC, RO and RE. Then (AE-RO) and (AC-CE) are calculated and represented on a graph that determine one's ultimate learning styles [20].
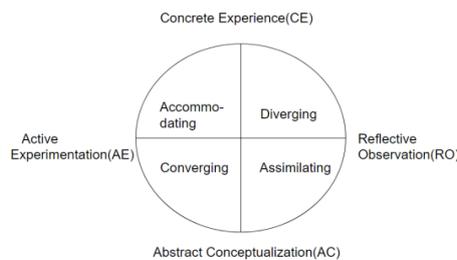
Concrete Experience(CE)

Accommo-dating | Diverging

Active Experimentation(AE) | Reflective Observation(RO)

Converging | Assimilating

Abstract Conceptualization(AC)

Fig. 3: Kolb's Learning Style Dimensions

Myers Briggs Learning Style Model

Myers Briggs Type Indicator (MBTI) is a tool or instrument to determine one's behavioral and learning preferences. According to his theory, everything has connection to a natural phenomenon. The MBTI is based on the principle that the differences in behavior from one person to another can be expressed in terms of preferences between the polarities. MBTI uses four bipolarities [Fig. 4] to describe 16 different learning styles [21].

Myers Briggs LS Model

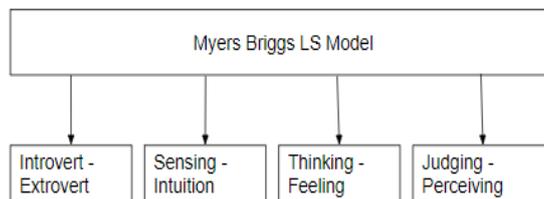Introvert - Extrovert | Sensing - Intuition | Thinking - Feeling | Judging - Perceiving

Fig. 4 Myers Briggs Learning Styles

- Introvert (I)-Extrovert (E): Introverts are generally introspective and are preferred to be alone. Extroverts prefer to work with groups.
- Sensing (S)-Intuition (N): Sensors are attentive to details and they acquire information gathered through their experience. Intuit-ors prefer innovative thoughts and abstract concepts.
- Thinking (T)-Feeling (F): Thinkers are impartial and they rely on objective rationalization to make decisions. Feelers are subjective
- Judging (J)-Perceiving (P): Judgers make rigid plan and structure before they start to work. Perceivers plan and work spontaneously [22].

Implementation of the Model:

A total of 16 personality types can be derived from the combination of above preferences. The personality types are identified using questionnaires and are denoted by 4 letters; in which each letter represents one kind of preference. For

example, ISTJ represents the person likely to be an introvert, sensor, thinker & judger [21, 23].

Neil Fleming Learning Style Model

Neil proposed a model with four learning styles such as Visual, Aural, Read/write, and Kinesthetic (VARK)[Figure5]. The aural learners learn from lectures, discussions etc. The reading or writing learners learn from textbooks, lecture notes, handouts, etc. The visual learners learn from pictures, graphs, charts, diagrams, etc. The kinesthetic learners learn by doing, i.e. from practice sessions, field trips, experiments, role-playing or simulation etc.
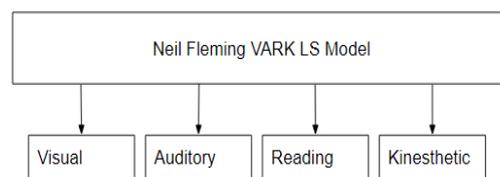

Fig. 5: Neil Fleming Learning Styles

Implementation of the Model:

In order to detect the preferences of students, VARK model developed a set of questionnaires that could serve as a diagnostic tool [24].

3. Identifying Learning Styles in a Classroom by Analyzing Student Preferences

To design E-learning system, a platform for working with activities and problems and to solve problems has to be developed. The learning styles of students can be determined by analyzing their preferences in classroom learning. The models are using a set of questionnaires. The students are required to answer the questions with a predefined value set. Based on the ratings they give students are grouped into different learning styles. The instructor would provide different activities and problems with a textual or visual mode to solve them by the students. The instructor would watch the ways and strategies used by the students to solve. Some students prefer to take the problems in textual mode, while others in visual mode. Some will answer in textual mode, while the others in visual mode. Some solve the problem in several steps, while others need only one step. They also watch the interaction between the students. Some students prefer to be alone when solving the problems and the others would like to take part in groups. This can be identified as their learning styles [1].

For instance, in [16], 54 students were participated in an experiment. The participants are divided into two groups namely, experimental and control groups. In the first stage, students are asked to attend a class of fundamentals of

computer networks. Then a pretest is conducted to check their learning in basics. After that, experimental group and control group required to follow personalized E-learning and conventional E-learning respectively. After completing the learning process, a post-test is conducted and the result is analyzed. The result says that a better learning has happened in personalized E-learning than conventional E-learning.

4. Personalized E-learning System

The personalization in E-learning can be achieved by identifying the learning styles of each student using any proposed LS model. As discussed in the above section, different models will result in the learning styles using different approaches. An E-learning environment without personalization will not take the learner's abilities, knowledge, and experience into account. The system will not be interactive in terms of feedbacks and reviews [25]. The personalized E-learning system allows organization and mapping of contents automatically so as to fit the learner needs [26]. Personalization brings every individual to learn and improve their knowledge according to their learning styles.

For the construction of personalized E-learning system, the system must include a learner module, a domain module, and a personalization module. The learner module consists of learner's personal profiles and their learning styles. The domain module includes the contents such as theories, problems, questionnaires, videos etc. to learn. The Instructor will add the contents to the domain module and update according to the preferences of learners. The personalization module is considered as the base of the learning system, which maps the contents specific to the appropriate learning styles in the learner module and generates different learning interfaces for different learner groups [27]. The system is implemented with any recommended learning style model which includes set of questionnaires, rules and tests for finding the learning styles. The model generates the learner profile containing the elements such as personality, preferences, knowledge etc. [28], [29].

The learners, when entered into the system go through the assessment process with a set of instructions and questionnaires to measure their prior knowledge with the ratings they give and to predict learning styles accordingly. Based on the learning styles identified each individual learns through the recommended ways of learning and thereby they can improve their quality of learning.

5. Proposed System

The purpose of this study is to identify a model that helps the autistic students to detect their learning styles and to thereby improve their E-learning. Studies have suggested that autistic students have a special interest in computerized learning [30]. Not only the computers, the technology used for E-learning ranges from Smartphone to robotics [9]. Students with autism have learning challenges that make them difficult to learn. Each autistic student differs with their ASD

characteristics. The identification of their learning styles is also difficult. The table IV shows the learning styles or preferences of autistic students [31].

Not every student has the same challenges and each one learns in different ways. In this paper, we consider linguistic, spatial, logical-mathematical learning styles to study the topic. Since, the paper focuses on studying their academic learning through E-learning methods. Linguistic learners have the ability to speak, read and write. They prefer to learn from lecture notes, lectures, etc. Spatial learners like to learn visually from pictures, videos etc. and to express their knowledge in charts, diagrams etc. Logical-mathematical learners involve in logical thinking and solve problems and make patterns or rules.

The learning styles of autistic students can be captured in the classroom learning by providing different problems, theories, and activities. The same problem or activity can be solved fully or partially respective of the student's ability, in different ways. These learning styles can be analyzed during the classes and grouped into different styles such as linguistic, spatial and logical-mathematical. Each group of learner can then learn with suitable learning materials according to their learning styles.
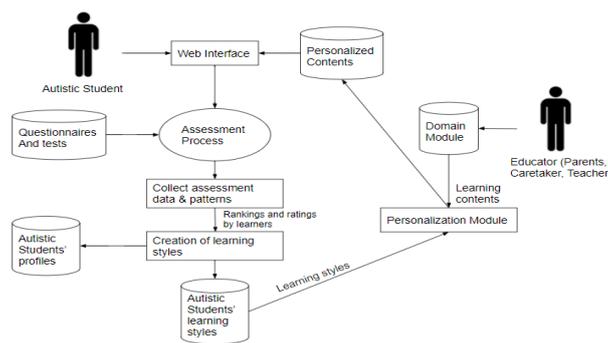

Fig. 6: Personalized E-learning System

In order to bring personalization in E-learning system for autistic students, the system should adopt a learning style model which is more suitable for their learning characteristics. The diagrammatic representation of the system for autistic students is given in Fig. 6. As autistic students have challenges they will have instructional support from their parents or caretakers to answer the questionnaires and to follow the rules. The educators (Parents, Caretaker and Teacher) will provide the learning instructions and materials into system according to the students' preferences and needs. Once the system has identified their learning styles, the system will give personalized learning contents.

From the above discussed learning style models, we prefer Felder-Silverman model and VARK model, which have defined learning styles that almost fit the autistic learning styles.

The Neil Fleming VARK model defines learning styles such as aural, reading-writing, visual and kinesthetic. From these styles, the aural, reading-writing and visual styles are similar for autistic learning styles. But, the mathematical style of learning is not considered in the VARK model. Similarly, the learning style dimensions sensing/intuitive, global/sequential and visual/verbal of Felder-Silverman will fit with the autistic learning styles. The sensing/intuitive learners like solving problems in different methods. The sequential learners solve problems in small incremental steps and global learners in large steps. This type of dimension will match the mathematical style of autistic learning. The visual/verbal learning is the type by which the autistic students learn by watching videos, pictures or from the lectures, written documents, etc. Thus this model supports the three learning styles of autistic students. Also, Felder-Silverman model gives a detailed description of each dimension and from the selected three dimensions; it is possible to generate 8 different learning styles of autistic students [4]. Thus, this paper takes Felder-Silverman model as the best of other models to develop personalized E-learning system for autistic students. The other models such as Myers Briggs model, Kolb's model, Honey and Mumford model suggest learning styles more from the students' cognitive behavior i.e., according to their thinking, planning, judging or remembering capability, which is clear from their definition. The questionnaire according to FSLSM will identify the 8 different learning styles and according to the value of each three dimension, the autistic students learn through their preferred ways of learning.

Table IV: Autistic Students' Learning Styles

Autistic Students' Learning Styles	Characteristics
Linguistic learners	They have speaking, reading and writing abilities to learn things.
Musical learners	They like to hear or sing music.
Logical-mathematical	They like to solve problems, patterns, etc.
Bodily-kinesthetic	They learn from activities like movements, games and hand on tasks.
Naturalistic learners	They love outdoors, animals and field trips.
Spatial learners	They learn from visually and organize their environment spatially like maps, charts, etc.
Interpersonal	They like others friendship and presence and like to work in groups.
Intrapersonal	They like to play and work alone.

6. Conclusion

This paper discussed the learning styles models such as Honey and Mumford model, Felder-Silverman model, Myres Briggs model, Kolb's model and Neil Fleming model, which is used to generate learning styles of autistic students so that their E-learning can be improved according to their needs and preferences. The autistic students learn differently from normal students as they have several challenges. The paper theoretically says that learning styles models can apply not only to normal students but for autistic students. The paper recommended two models i.e Felder-Silverman and VARK model, from which the Felder-Silverman model has taken as the better for autistic learning. By providing personalized E-learning environment, each autistic student can learn differently according to their learning styles and also to improve their knowledge and skills.

The paper also tells about the different modules used for personalization and how they are implemented. Each component has its own activities to provide effective E-learning based on the individual's learning styles.

7. Future Work

The paper theoretically suggests developing a personalized E-learning platform for autistic students with the specified learning styles models so that their learning can be made effective according to their learning styles. This helps both the students and instructors since it is difficult for an autistic student to learn and instructors to teach. Developing such a system in the future will be beneficial for autistic students to improve their knowledge with their own preferences and needs. The future work of this study will be to collect experimental data of autistic students in a classroom and analyze the results to provide a practical conclusion for the study.

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