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Learning Styles and Cognitive Traits in an On-line Learning System

Catherine Elizabeth Vucetic Trifirò
London, United Kingdom

Gregory Kenneth Laing
University of Canberra, Australia

Abstract

Purpose: *The purpose of this paper is to examine the various models concerned with identifying learning styles and cognitive traits of students as a means to adapt teaching methods. With attention to the applicability of the models to on-line teaching strategies and requirements.*
Design/Method/Approach: *The approach adopted in this paper is one of reviewing the prior research on models for learning styles and cognitive traits as applied to on-line learning.*
Practical Social Implications: *This review provides some direction for future research in light of the growing use of on-line learning.*

Key words*: Learning styles; learning management system; cognitive traits; on-line learning/teaching.*

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Introduction

Since the advent of the COVID 19 pandemic all educational institutions have undergone dramatic changes in the way they engage with students (Castro & George, 2021). The most dramatic move has been the adoption of on-line learning/teaching where the only interaction is with a computer screen, and this ignores the fact that students are individuals with diverse skills and learning abilities (Aragon, Johnson & Shaik, 2001; Ginnis, 2002). On-line learning techniques have been growing in popularity as a means for dealing with the growth in higher education student numbers (Riffell & Sibley, 2005; Iverson, Colky & Cyboran, 2005; Clark & Mayer, 2007) so it was an obvious solution to deal with the isolation requirements imposed by the Covid pandemic. However, as Laing (2020) argued it would be a mistake to think that all students are the same and that they can be expected to fit one generic teaching method. Research has supported the notion that students do not find on-line learning to be as useful as face to face (Banna, Lin, Stewart & Fialkowski, 2015; Hilton, Moos & Barnes, 2020; Zhang, Addae, Bakeman, et al. 2020).

Students are not the only ones affected by their learning style teachers are just as likely to be influenced in the way they teach by their own learning style preferences (Stitt-Gohdes, 2001; Ebeling, 2000). Thus, what emerges is the need for teachers to be self-aware of their own learning styles when developing teaching methods for students. To address this issue the Models of learning styles and preferences can allow teachers, personal tutors, and support staff to take a constructive approach to effectively differentiate, teaching directly to the ability of the individual student, building confidence, whilst also stretching, challenging, and developing other learning abilities and study skills. This combined humanistic approach enables the teacher to develop the whole student and their academic ability and skill to reduce barriers, progress and therefore gain qualification and (or) employability with confidence and competence.

Learning Definitions

There are various definitions of the concept of learning however for the purpose of this paper the following are presented for consideration –

> "*For the brain to learn, it needs to change the way neurons get activated by situations in the future. Mostly this is done by changing the strength of the connections between neurons*." (CEN, 2020)

The inference is that there are at least eight learning systems in the brain and that connections between the neurons (synapse) develop at different rates, some faster and slower than others (CEN, 2020).

These learning systems within the brain are considered to be connected, interconnected, integrated, and are constantly communicating and interacting. With age, life experience and accumulation of skill and knowledge, learning continues through connection to previous learning. Therefore, learning can also happen jointly, together with previous learning and severally through new neuro connection and synapse.

"… learning is an ongoing process, occurring over the span of one's lifetime and delivered by a variety of instructors with a variety of teaching styles in a variety of situations, learners need to be able to adjust their cognitive styles." (Brown, 2003)

> *"Learning is at least in part defined as a change in long term memory. For this we can draw on a growing evidence base from the 'learning sciences' a new interdisciplinary field that seeks to apply cognitive science to classroom practice".* (Ofsted, 2019, 15-16)

This definition has draws support from cognitive load theory (CLT) which implies that before entering long term memory, information must be first processed by the short-term working memory. Storage and transfer from short term to long term memory cannot happen if the working memory is overloaded. (Ofsted 2019 p 15- 16). Thus, as students gain more study experience, their working memory should expand over time, allowing for greater quantities of information to be processed and transferred from the working short-term memory into the long-term memory and the rate of learning should increase.

In the psychology literature there are two distinct classifications for defining learning – the functional concept and the mechanistic concept *(De Houwer, Barnes-Holmes & Moors, 2013). A basic functional concept is that learning is an effect of experience on behaviour (Lachman, 1997), whilst from a mechanistic concept learning is an enduring change in the mechanisms of behaviour (Domjan, 2010).* These psychological concepts strongly suggest that cognitive traits as well as personality traits of individuals are influential in delineating learning styles.

Learning Styles

There has been considerable research into the learning styles of students (Aragon, Johnson & Shaik, 2001, 2002). Research has emphasised the importance of learning styles in achieving successful educational outcomes (Beck, 2001; Loo, 2002, 2004). Coffield et al (2004) identified the existence of seventy-one established learning styles. However, the most common models for considering learning styles are:

- The Kolb (1984) Learning style inventory (LSI) which is linked with the Experiential learning cycle and takes the view that learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations. Kolb's four learning styles are:
    - **Diverger**: combination of CE and RO Feeling and Watching = Concrete Experience and Reflection of the experience. Imaginative and good at planning out ideas
    - **Assimilator**: combination of RO and AC Watching and Thinking = Observation and Thinking
    - **Converger**: combination of AC and AE Thinking and Doing = Thought and Active experimentation
    - **Accommodator**: combination of AE and CE Doing and Feeling = Actively experimenting and the concrete experience of that.

- The Honey and Mumford Learning Styles Questionnaire (LSQ) is a derivative of the Kolb LSI however, it focuses on behaviour preferences, motivations and tendencies in contrast to that of learning. Thus, the learning styles are identified along different lines as:
    - **Reflectors**;
    - **Theorists**;
    - **Pragmatists**;
    - **Activists**.

- The Flemming Learing Styles are focused on each students preferred mode of communication and the preferences are identified as:
    - **Visual**;
    - **Auditory**;
    - **Read / Write**;
    - **Kinestirtic**;

  The model is commonly referred to by the mnemonic "VARK".

- The Herrmann Whole Brain Dominance Instrument (HBDI) (Herrmann, 1996) is based on the notion that learning styles conform to the neurology of the left and the right brain (Herrmann, 2014). The Model relates to the thinking preferences of;
    - **Rational**;
    - **Practical**;
    - **Experimental**;
    - **Relational**.
- The Felder and Silverman (1988) learning style model has similar constructs to both the Kolb and Fleming models, however, they are contrasted along opposing dimensions. That is the four dimensions in this model are:
    - **active-reflective**; learning by doing vs learning by reflection;
    - **sensing-intuitive**; concrete practical experience vs abstract more innovative;
    - **visual-verbal**; learning from observation vs learning from being told;
    - **global-sequential**; learning from total perspective or the big picture vs learning by linear steps with a focus on details

- The Lin, Kinshuk and Patel (2003) learning styles model takes a different approach profiling learners according to their cognitive traits. The various cognitive traits (Lwande, Muchemi & Oboko, 2021) encompass such areas as:
    - **Working Memory capacity**: ability to briefly concentrate and retain information -
        - **High Working Memory Capacity**: consigned to cognitive styles – field-independent, divergent – serial;
        - **Low Working Memory Capacity**: consigned to cognitive styles – field-dependent, convergent – holistic;
    - **Associative Learning Ability**: ability to link new knowledge to existing knowledge;
    - **Inductive Reasoning Ability**: ability to understand and create concepts from examples;
    - **Information Processing Speed**: the speed at which an individual can retrieve information from memory and make correct decisions.

There are a number of definitions for metacognition, the earliest one is by Flavell (1976, 232) "*Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them*". Research has shown that metacognition plays an important role in the learning process (Alexander, Fabricius, Fleming, Zwahr, & Brown, 2003; Mayer, 1998; Panaoura & Philippou, 2004). There is also evidence that learners with high metacognitive abilities can perform better in problem solving tasks (Lester, Garofalo, & Lambdin-Kroll, 1989; Mayer, 1998).

Metacognitive learning (and teaching) strategies can be instrumental in the utilisation of the various learning preferences:

- Concrete experience (doing) or case study of a potential client's hair and requirements (reading) (reflecting) (writing).
- Spaced practice (read / write/ aural / visual (break) (kinaesthetic) (break) (read / write), theory then lunch then practical then theory.
- Elaboration (aural) (write) brainstorming, mind mapping, group work and:
- Dual Coding (read and visual) or (visual and aural) or (kinaesthetic and write) a power point with an image and a question or a practical

demonstration or a video with a voice explanation or a step-by-step practical activity with a step-by-step record activity.

Table 1:
Comparison of Basic Learning Style Models

Style / Preference	**Principles of each Style / Preference**			
Kolb (LSI) *Learning Experience*	CE +RO **Diverger** Feel + Watch	RO + AC **Assimilator** Think + Watch	AC + AE **Converger** Think + Do	AE + CE **Accommodator** Do + Feel
Honey & Mumford (LSQ) *Learning Experience*	CE +RO **Reflectors** Feel + Watch	RO + AC **Theorists** Think + Watch	AC + AE **Pragmatist** Think + Do	AE + CE **Activist** Do + Feel
Fleming "VARK" *Communication tool*	**Read / write**	**Visual**	**Auditory**	**Kinaesthetic**
Hermann (HBDI) *Thinking preference*	**Left Brain** A - Blue **Rational** Logical Analytical Fact Based Quantitative	**Left Brain** B - Green **Practical** Organised Sequential Planned detailed	**Right Brain** D - Yellow **Experimental** Holistic Intuitive Integrating synthesising	**Right Brain** C - Red **Relational** Interpersonal Feeling Kinaesthetic Emotional
Felder & Silvermann Learning Style Dimensions	**Sensing** Learn from practical experience **Reflective** Learn by thinking	**Seguential** Learn from step by step **Visual** Learn by watching	**Verbal** Learn by listening **Intuitive** Learn by instinct	**Active** Learn by doing **Global** Learn from big picture

Abbreviations: CE = Concrete Experience RO = Reflective Observation
AC = Active Conceptualisation AE = Active Experimentation

Table 2:
Comparison of Felder & Silverman Learning Style to Working Memory Capacity

Lin, Kinshuk & Patel Cognitive Trait	**Low Working Memory Capacity**	**High Working Memory Capacity**
Felder & Silvermann Learning Style Dimensions	**Active** Learn by doing	**Reflective** Learn by thinking
	Sensing Learn from practical experience	**Intuitive** Learn by instinct
	Visual Learn by watching	**Verbal** Learn by listening
	Global Learn from big picture	**Seguential** Learn from step by step

Source: Adapted from (Graf, Lin & Kinshuk, 2005, 2008)

Discussion on Learning Styles

Kolb's Learning Style Inventory (LSI) in essence supports the development of the whole learner and this humanistic approach looks to support the development of other skills and abilities and how they relate to each other in the learning of a skill or knowledge. However, labelling a student as having one learning style alone may become confusing and limiting to both the teacher and the student, as each learning style as defined by the cognitive and preferred behavioural tendency. Another deficiency with the LSI is the lack of support for its reliability and construct validity (Ruble & Stout, 1994).

The Honey and Mumford Learning Styles Questionnaire (LSQ) is modelled on the Kolb LSI framework and as such shares much the same benefits. The main difference being that it is useful as it probes attitudes and behaviours, personal organisation, and organisational development, which addresses the weakness in Kolb's model of labeling people as residing in one category, when most people can exhibit more than one strong preference (Coffield et al, 2004). However, this model also has a lack of evidence pointing to any statistically significant pedagogcial impact. Further, the LSQ was developed for professional occupational use, and therefore aimed at adult participation. It is important to note that in Further and Higher Educational insitutions there may be an age range from sixteen plus, and that as students gain life experience and mature, their learning style may also develop and change.

Fleming's VARK model acknowledges multi modal preference, allowing for students who do not have a specific learning preference but rather have a combination of two or all four preferences. As with the first two models this model also suffers from the lack of any statistically significant evidence to justify or otherwise confirm the existence of a pedagogcial impact. However, viewing learning preferences as a preference of communication and not as a set style, is to some extent a useful and positive tool to utilise in professional, academic and personal life. It establishes physiological strengths that individuals can use throughout their life. The VARK model could be readily utilised in the primary, secondary and further education sectors as a diagnostic tool and as a benchmark to ensure sensory diversity of resources, activities, and teaching materials.

Herrmann's Whole Brain Dominance Instrument (HBDI) was developed as an instrument to understand how people think, not how people learn, therefore it is a non-labelling, non-judgemental tool used to validate all thinking. This supports the development of critical thinking, organisational, interpersonal, and intrapersonal skills. It enables students to understand when one preference of thinking may be needed over the other and this can be used to also develop employability skills, attitudes, and behaviour management. When the HBDI is completed, it creates an individual personal profile. The HBDI system acknowledges that an individual grows and changes in life, and that that one's thinking can also change and develop. As it is based on the neurological capability of the human brain, it has a solid foundation in the research literature arena. Although not widely used in education, it is "sound", due its wide international online database and due to its diverse approach it has potential for use in the education sector (Coffield, 2014).

On-line Learning

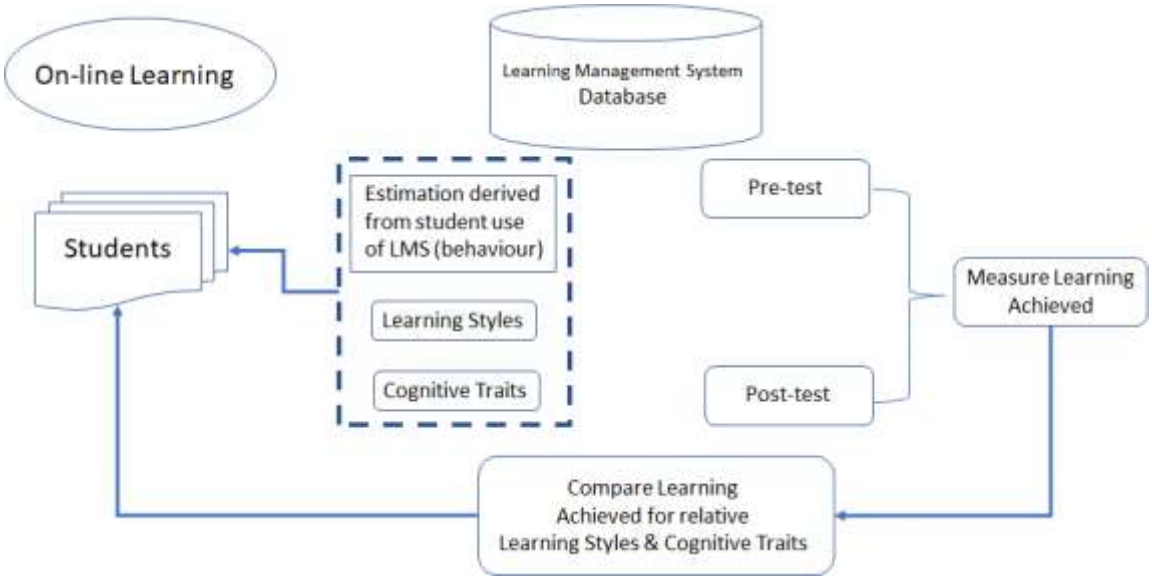
It is worth noting that none of the models were developed with any consideration of the needs that would arise from the predominance of on-line learning (alternatively referred to as e-learning). The very nature of on-line learning involves the use of visual and auditory senses, so much so that it would appear to favour those individuals with learning styles that are predominantly related to visual and auditory learning.

On-line learning has led to the rise in Learning Management Systems (LMS) such as Moodle, Claroline, and Blackboard (Don, 2014) all intended to facilitate teaching, however, none of these have any specific features for analysing data and identifying student behaviour such as learning styles and cognitive traits. Subsequently, there has been very limited research into measuring the performance of students with differing learning styles or cognitive traits and the acquisition of knowledge from on-line learning.

Early research (Graf & Kinshuk, 2007; Carver, Howard & Lane, 1999) sought to provide adaptivity in the learning management system to match the learning style of students. The learning style of students was typically identified by way of a self-administered questionnaire. The most promising research, however, was that of Lwande, Muchemi and Oboko (2021) which sought to establish a model for the estimation of learning styles and cognitive traits from within a learning management system. The model successfully extracted data from the Learning Management Systems and was able to estimate the learning style and cognitive traits of the students. Unfortunately, the study did not provide any details of the performance of the students within the various learning styles or cognitive traits. This is obviously a matter for future research since the outcome of any on-line learning should be relative to the learning by the individual students. Here too the learning management system can be used to gather the required data such as pre-test versus post-test of each individual student's knowledge to measure the extent of any learning.

Taking the model developed by Lwande, Muchemi and Oboko (2021) with learning styles and cognitive traits being identified from within the learning management system and then matching the performance of student's pre-test versus post-test the following model is constructed for future research (see Figure 1).

Figure 1:
Model for Evaluating Learning from within the Learning Management System



Summary

Kolb's experiential learning model and the Honey and Mumford LSQ provide for pedagogical learning strategies enabling inclusive learning. However, as each student experiences the information communicated to them as it is taught the VARK model addresses issues in regards to how learning can be influenced by the way knowledge is communicated to students.

The use of experiential learning within a vocational course supports the qualification employment skills, and employability skills making it an excellent teaching and learning tool. This approach to inclusive constructive learning means that each student with different learning styles / preferences should develop their strengths and weaknesses as they relate to employability skills (literacy, numeracy, information technology, problem solving, self-management).

The metacognitive learning strategies enable students to learn constructively and support the concept of experiential learning so that learning is experienced and constructed with guidance of the tutor whilst engaging each student.

Inclusion learning is fundamentally enabled through inclusive teaching. Identifying and taking into account students individual learning preferences, enables their learning to be stimulating, engaging, and challenging. Resulting in a positive, supportive, and developmental learning environment. Equal, diverse, and inclusive practice allows students equal opportunities to experience learning in as many ways as possible within the lesson via diverse resources and learning activities that do not discriminate or exclude and offer equal learning opportunity to each individual learner.

The main problem facing the educational sector is finding a means to address these educational needs of students in an on-line setting. When on-line teaching means that the resources learning activities are constrained and otherwise limited the means to provide experiential learning becomes difficult. Further research needs to be conducted to analyse the effect that on-line learning is having on students with different learning styles / preferences and what if any relationship this has with cognitive or behavioural traits.

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