The Relation between Learning Styles according to the Whole Brain Model and Emotional Intelligence: A Study of University Students

Relación entre los estilos de aprendizaje según el Modelo de Cerebro Total y la inteligencia emocional: un estudio en estudiantes universitarios

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Resumen: Durante las últimas décadas ha existido un profundo interés en la literatura por ahondar en los estilos de aprendizaje a fin de desarrollar las metodologías más eficaces en el proceso de enseñanza/aprendizaje. Sin embargo, pocos estudios han analizado la relación existente entre los estilos de aprendizaje según el Modelo de Cerebro Total y la inteligencia emocional en alumnos universitarios, que es esta la propuesta implícita en este trabajo. Metodología: Para la medición de los estilos de aprendizaje dominantes se utiliza el *Diagnóstico Teoría de Cerebro Total,* que es una adaptación reducida del instrumento de medida *Herrmann Brain Dominance Instrumen*t. En relación a la medición de la inteligencia emocional se utiliza una adaptación simplificada de la versión castellana del *Trait Meta-Mood Scale.* Resultados: Los estilos de aprendizaje basados en dominancias mixtas influyen de forma positiva en el desarrollo de la inteligencia emocional. Por otro lado, se observa una contribución más pronunciada de los estilos de aprendizaje asociados al hemisferio derecho en el desarrollo de la inteligencia emocional. Conclusiones: Existe una necesidad de entrenar a los estudiantes en el uso de un estilo de aprendizaje que permita el uso de dominancias mixtas, para contribuir así al desarrollo de su inteligencia emocional.

Palabras clave: Estilos de Aprendizaje, Modelo de Cerebro Total, Inteligencia Emocional.

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Abstract: There has been considerable academic interest in learning styles in recent decades aimed at developing more efficient methodologies in the teaching-learning process. However, few studies have analysed the existing relationship between learning styles according to the whole brain model and emotional intelligence in university students, the proposal of the present research. Methodology: Dominant learning styles were measured with the *Whole Brain Theory Diagnosis*, a shortened adaptation of the *Herrmann Brain Dominance Instrument*. Emotional intelligence was measured using a simplified adaptation of the Spanish version of the *Trait Meta-Mood Scale*. Results: Learning styles based on mixed dominances positively influence the development of emotional intelligence. Learning styles associated with the right hemisphere were also found to have a greater impact on emotional intelligence. Conclusions: Students should be trained in a learning style that enables the use of mixed dominances, thereby contributing to the development of their emotional intelligence.

Keywords: Learning Styles, Whole Brain Model, Emotional Intelligence.

Introduction

One of the aims of the teaching-learning process is to give individuals the skills with which to interpret phenomena and events in their environment, thereby preparing citizens who will contribute to developing healthy and efficient societies. Intrinsic to the achievement of this goal is the preparation of autonomous professionals who are able to construct their own personal learning systems. This process involves strengthening intellectual skills, which include analytical intelligence, but also the social and emotional skills more closely related to emotional intelligence (henceforth EI). In recent years a growing body of research has shown the importance of training abilities related to the socialisation process, acquiring the competencies or skills related to this process, solidarity, tolerance, empathy, and self-esteem (Estrada, Monferrer and Moliner, 2016; Durlak, Weissberg, Dymnicki, Taylor and Schellinger, 2011). All these skills have an inevitable impact on an individual's personal and social development. In this regard, the business community is increasingly calling for universities to develop their graduates' EI, thus preparing them to successfully adapt to the world of work (González-Arias and Alucema, 2015). In responding to this concern, it is important to consider not only educational content, but also emotional education in its broadest sense. The development of professional competencies can only be guaranteed if the teaching-learning process also includes students' personal development (Rosa, Riberas, Navarro and Vilar, 2015); from the educators' perspective, therefore, the process requires an understanding of the learning styles students use. This understanding will help educators to effectively design the necessary strategies and methodologies for students to develop their knowledge and learning to the full.

Recent decades have seen a growing interest in the study of mental capacities that allow individuals to construct their own knowledge and learn how to face life situations effectively (Estrada, Monferrer and Moliner, 2016); Gómez, 2004; Perea, 2011; Segarra, Estrada and Monferrer, 2015). In this vein, Alonso, Domingo and Honey (1994) define learning styles as, "cognitive, affective and physiological traits that serve as relatively stable indicators of how students perceive interactions and respond to their learning environments". The concept of learning style is based on the unquestionable fact that everyone is different. This difference manifests itself in many forms and is reflected in traits such as age, experience, level of knowledge and interests, and the psychological, physiological, somatic and spiritual characteristics that shape each individual's personality. Learning style is related to knowing (how do I know?), thinking (how do I think?), affect (how do I feel and react?) and behaving (how do I act?). The wide variety of cognitive and affective elements intervening in the process means that each individual uses their own strategy for learning (Brookfield, 1995; Gómez, Oviedo, Gómez and López, 2011; Mallart, 2000). Defining all these theories on learning styles is an arduous task and the subject of some debate (Rojas, Salas and Jiménez, 2006). In the present study, rather than dwelling on these discussions we briefly describe the main theories in the literature before proposing a theoretical model that, based on the whole brain model, associates different learning styles with the development of EI in university students. The final objective of this study is to reflect on how to effectively cultivate and develop students' emotional intelligence in order to best prepare them for their future professional careers. To this end, we first introduce the theoretical frame undergirding this literature, defining the concepts of the whole brain model and emotional intelligence. Secondly, we propose the theoretical model that forms the basis for this study. We then present the methodology used for a sample of 853 university students enrolled on eight different degree courses, followed by an analysis of the results. The article ends with the study's conclusions and limitations, and a discussion of its implications for educators.

The Whole Brain Model

Advances in the study of cognition offer a conceptual framework and a useful methodology with which to approach all aspects of the mind and learning, including emotions. Since the times of ancient Greece, cognition and emotions have been regarded as separate and opposing aspects, emotions tending to be seen as subjective states of consciousness. This subjectivity meant they were initially "scorned" by cognitivism. However, advances continue to be made in research into other brain functions that do have subjective correlations and, therefore, the study of emotions must also be taken further. Psychologists studying emotions have attempted to explain them as cognitive processes. Emotions are thoughts about the situations in which we find ourselves and do not differ from cognitive acts. In sum, feelings and emotions are the way we explain emotionally ambiguous physical states to ourselves, using thought and attributions on the external and internal causes of this state. Emotions are the result of a cognitive interpretation of situations. One of the prime objectives of modern science is to locate these functions in the brain, as this information is essential to knowing how they work and how to activate them in the learning process. In what follows we provide a brief historical review of the predominant theories in the literature on the study of the brain and learning.

Sperry's (1961) pioneering research on the theory of left brain-right brain dominance prompted other work on learning styles such as the theory of the triune brain, the whole brain model, multiple intelligences, emotional intelligence, among others. These theories refer to the brain's anatomical and physiological composition in various structures that give individuals this integral character and allow them to see, feel, act, learn and live together, going beyond the capacities associated with obtaining information and taking decisions (Casado, Llamas and López, 2015).

Sperry's (1961) theory establishes that the two brain hemispheres control different types of thoughts, depending on which one each person prioritises. Thus, someone who uses the left part of the brain is more logical, analytical and objective, whereas those using the right side of the brain are more intuitive, reflective and subjective.

Some years later, the triune brain hypothesis (MacLean, 1990) argued that the brain has three structures. The first is the neocortex, consisting of the left and right hemispheres, the former associated with logical reasoning processes and breaking down a whole into its parts, and the latter concerned with the ability to see things holistically and establish spatial relationships. The second, the limbic system, is where emotional and basic motivational processes take place. Finally, the reptilian brain is where the processes controlling the routines and customs of human behaviour take place. Using these brain structures together allows people to take advantage of all their capacities in developing their learning.

Based on these studies, Herrmann (1989) devised the whole brain model, which divides the brain into four quadrants, two upper cortex and two lower limbic, in a metaphorical architecture in which each quadrant is associated with a particular learning, and therefore each individual's thinking process may be described according to their preferences for each of the four quadrants (Cazau, 2004; Maureira, Flores, Gálvez, Cea, Espinoza, Soto and Martínez, 2016; Silva, 2008). Thus, the upper left lobe (quadrant A) deals with logical-analytical thought; individuals with this brain dominance learn rationally and logically. The lower left lobe (quadrant B) is associated with sequential and planned thought; individuals with this dominance prefer organisation and routine. The lower right lobe (quadrant C) is related to emotional, communicative and humanistic thought; subjects with this brain dominance learn by conceptualising and integrating. Finally, the upper right lobe (quadrant D) is associated with conceptual, holistic-intuitive and creative thought; subjects with this brain dominance learn by listening and asking questions (Flores and Maureira, 2015; Gardié, 1998; Gómez, Oviedo, Gómez and López, 2011; Velásquez, Remolina and Calle, 2007). Each individual tends to use the functions of one hemisphere more than the other –brain dominance– to interact with their environment (Herrmann and Herrmann-Nehdi, 2015; Said, Díaz, Chiapello and Espindola, 2010; Salas, Santos and Parra, 2004; Sánchez, 2010). This preference affects personality, skills and learning style, which led Herrmann to postulate that brain dominance is related to the way we prefer to learn, understand and express something (Rojas et al., 2006). Based on this idea, Herrmann devised the *Herrmann Brain Dominance Instrument* (HBDI) to determine each person's characteristic dominance profile. This instrument establishes four learning style modalities: 1) realistic, belonging to the left hemisphere (quadrants A and B); 2) idealistic, belonging to the right hemisphere (quadrants C and D); 3) pragmatic (quadrants A and D); and instinctive (quadrants B and C) (Herrmann and Herrmann-Nehdi, 2015; Flores and Maureira, 2015; Maureira, Aravena, Gálvez and Cea, 2014; Segarra, Estrada and Monferrer, 2015).

These modalities imply a preferred way of knowing, which is the one an individual is most likely to use when resolving a problem or selecting a learning experience. The way a challenge is met will vary according to whether it is approached from the left brain (or logical hemisphere), concerned with the details, parts and processes of language and linear analysis, or from the right brain (or gestalt hemisphere), dealing with images, rhythm, emotion and intuition, to synthesise all parts within an intuitive sense of the whole. The preferred way of knowing is therefore strongly related to *what* we prefer to learn and *how* we prefer to learn it. In sum, it is each person's preferred approach to thinking emotionally, analytically, structurally or strategically, and according to the model proposed in this study, this predicts the way individuals manage the emotions they experience during the learning process.

Emotional intelligence

In the previous section we referred to some of the predominant theories in the literature on how the brain functions. This leads us to consider the trilogy of mind proposed by Hilgard (1980) and frequently used as a model for classifying personality. In this tripartite division, emotions are one of the three basic operations of the brain, together with cognition and motivation. Cognition (what I know) allows a mental representation of reality; motivation (what I want) activates and guides behaviour; and emotion (what I feel) encompasses the subjective experience of the activation, its meaning and its behavioural expression. Although these operations are understood to be different, it is recognised that they are related to and constantly interact with each other, penetrating cognitive processes and the acquisition of knowledge (LeDoux, 2002). However, they have traditionally been studied as separate and even conflicting aspects (Salomon, 1993). This is the case of the cognitive revolution in the second half of the twentieth century, which marked the beginning of a new stage in which the influence between cognition and emotion was established. Emotion was shown to affect cognition, as illustrated by the findings of cognitive research in the 1980s and 1990s (Blaney, 1986); this was furthered by advances in the field of neuroscience on the value emotional response adds to decision making and learning (Damasio, 2006).

In addition to the above, the concept of intelligence became more flexible (Gardner, 1993; Guilford, 1985), practical intelligence was posited (Sternberg, 1985) and the general capacity to learn and adapt to the environment in a flexible and effective manner was included as an indicator of intelligence (Gardner, 1993). Thus emerged the *Model of Multiple Intelligences* (Gardner, 1993), which proposed eight different forms of intelligence, each one associated with a form of mental representation: logical intelligence, pertaining to the sciences; linguistic intelligence, expressed in good writing; spatial intelligence, involving a three-dimensional mental model; kinaesthetic intelligence, the body's ability to perform activities; naturalist intelligence, needed to observe nature; musical intelligence, typical among dancers; and finally intra-personal and inter-personal intelligence, which make up what would later be called emotional intelligence (henceforth EI), and determine the ability to satisfactorily manage behaviour through life. These intelligences are different and independent, and can be strengthened independently.

In the wake of the above models, new studies on EI have appeared in recent years, mainly exploring its potential for achieving everyday goals (López-Zafra, Pulido-Martos, Berrios and Augusto-Landa, 2012; Pérez-Fuentes, Molero, Gázquez and Soler, 2014; Warwick and Nettelbeck, 2004). EI is the result of specific mental and psychophysiological processes, the organisation of which involves different ways of understanding the world and learning (Akhtar, Boustani, Tsivrikos and Chamarro-Premuzic, 2015; Andrei, Siegling, Aloe, Baldaro and Petrides, 2016; Fernández-Berrocal and Ramos, 2004; Momm, Blickle, Liu, Wihler, Kholin and

Menges, 2015; Petrides, Mikolajczak, Mavroveli, Sánchez-Ruiz, Furnham and Pérez González, 2016; Vallés, 2008).

The analytical perspectives used to study EI include: 1) Theoretical Models of Ability (focusing on mental abilities that allow information coming from emotions to be used to enhance the cognitive process), and 2) Mixed Models (which combine mental abilities with personality traits). According to the proponents of Ability Models (Mayer and Salovey, 1995), EI involves a set of interrelated cognitive abilities representing the intersection between general mental capacity (reasoning) and emotions, and differ from the personality and behaviour traits (empathy, assertiveness, etc.) defended in Mixed Models. This perspective holds that EI is arranged in a hierarchy of aptitudes or branches.

Mayer and Salovey (1995) originally postulated that EI could comprise three mental abilities: assessment and expression, regulation (or management), and use of emotions. These authors built on this construct, resulting in the presentation and subsequent development of their four branch model. This new conceptualisation of EI reformulated the initially proposed abilities to include a new aptitude –understanding emotions– and distinguishes between capacities oriented towards emotional experience, and those oriented towards their transformation. The authors consider EI as a mental capacity structured in four levels: perceiving emotions, facilitating emotions, understanding emotions and regulating emotions (Mayer and Salovey, 1997). The three-dimensional conceptualisation of EI has been widely embraced in the Spanish and Latin American context. In this line, Fernández-Berrocal and Ramos (2004) proposed a conception of EI in three processes: perception (conscious recognition of emotions and identification of what one feels, and the ability to name emotions); understanding (integration of what one knows into one's thoughts, and the ability to consider the complexity of emotional changes); and regulation (guiding and managing both positive and negative emotions efficiently), which has been upheld by many authors (Carranza-Lira, 2017; Cejudo, García-Maroto and López-Delgado, 2017; Estrada, Monferrer and Moliner, 2016; Gónzalez-Cabrera, Pérez-Sancho and Calvete, 2016). This is due in large part to the simplicity and low cost of administrating the *Trait Meta-Mood Scale* (TMMS; Salovey, Mayer, Goldman, Turvey and Palfai, 1995) measurement instrument, which these authors have simplified and adapted to the Spanish context.

Leaving aside the conceptual disparity surrounding the study of emotional intelligence, there does appear to be a consensus that when emotion is perceived it intervenes at the basic level of processing, facilitating activities such as problem solving and decision making (Antonio-Agirre, Esnaola and Rodríguez-Fernández, 2017; Escoda, 2016). This consideration favours attention processes by redirecting attention to the information required in these circumstances (Mayer, 2001).

Learning styles based on the whole brain model and emotional intelligence

There now appears to be a certain agreement on the widespread belief that individuals cannot learn in isolation from their emotions, but that they also need to know how to manage them. According to Herrmann's (1989) postulates, this emotion management does not seem to fall exclusively into one single quadrant, but is present through the development of EI in the whole cognitive process entailed in learning. Effective education will therefore improve academic performance notably when students are trained to use the four brain quadrants (Gómez, 2004). Indeed, Herrmann (1989) holds that one hemisphere is no more important than the other, arguing that both are needed to carry out all tasks, especially complex ones.

The use of mixed learning strategies, Gardié (1998) argues, strengthens overall development and brings individuals closer to academic excellence by allowing a diverse range of resources and opportunities to develop. Thus, although the brain is structured in hemispheres and quadrants, each with its own specific functions, all of them are needed to manage emotional information efficiently, and thus improve effectiveness and performance. These arguments lead to the following hypothesis:

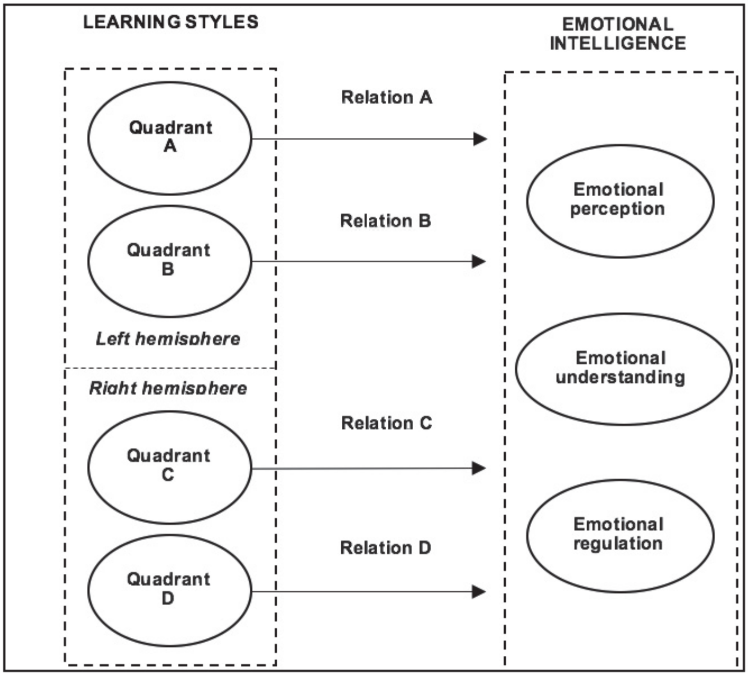
Hypothesis 1: Learning styles based on mixed dominances positively influence the development of students' emotional intelligence.

As noted above, each person has their own way of learning with a preference for one or other hemisphere (Casado, Llamas and López, 2015; Desrosiers, 2005; Mayolas, Villarroya and Reverter, 2010). A person with dominance in quadrants A or B tends to be methodical, describe processes and enjoy making sense of results, and thus is positively related with a theoretical learning style. These characteristics differ in individuals with dominance in quadrants C or D, who prefer aesthetics, emotions, new experiences and interpersonal relationships, and act according to their feelings; they favour a more active and emotional learning style over the rationality of the latter (Maureira, Aravena, Gálvez and Cea, 2016). We therefore propose the following research hypothesis:

Hypothesis 2: Learning styles associated with the right hemisphere make a greater contribution to the development of students' emotional intelligence.

These two general hypotheses are addressed by means of a model of relations (Figure 1) designed to test the possible influence each learning style proposed by the whole brain model has on the three dimensions of students' emotional intelligence.

Figure 1. Model of the effects of learning style on students' emotional intelligence



Having set out the research hypotheses, we now describe the research methodology and present the results. The paper ends with a discussion of the main conclusions and recommendations.

Method

Sampling and Data Collection

To test the research hypotheses and in order to cover the typologies from previous studies, we focused on second and third course students from eight academic specialities taught at the Universitat Jaume I of Castellón (Spain) structured in three different branches corresponding to each faculty (Humanities and Social Sciences, Experimental Sciences, and Law and Economics).

A questionnaire was designed and pretested on a pilot sample of 25 students. An electronic version of the questionnaire was then prepared and a link to it was included in the virtual classrooms of each subject in the study. Students were invited to complete the questionnaire, with particular emphasis on the following three points: (1) the data obtained from the questionnaire would be used solely for research purposes, and the survey was therefore not connected to evaluated course content in any way; (2) respondents were guaranteed full confidentiality and anonymity, as the data would be aggregated and in no case treated on an individual basis; (3) participants were asked to respond sincerely in order to safeguard the value and objectivity of the data obtained. In sum, the students were clearly informed that the questionnaire was not a test or exam, and therefore there were no right and wrong answers, but rather personal preferences and expectations for each of the aspects dealt with. By following these steps we hoped to avoid the social desirability bias that can arise if students respond with the social purpose of projecting a distorted image, whether positive or negative (Fernández-Berrocal and Extremera, 2005).

The fieldwork undertaken with a convenience sample during the second semester of the 2015-2016 academic year. We obtained 853 valid responses divided equally among the three faculties.

Of the total, 467 were women (54.7%) and 386 were men (45.3%). The students' age range was between 19 and 22 years, with an average value of 20 years. Table 1 reports the descriptive data for the sample regarding learning styles and emotional intelligence.

Table 1. Summary of the descriptive analysis of the sample

FACULTY (N; %)	DEGREES (N; %)	LEARNING STYLES M (SD)				EMOTIONAL INTELLIGENCE M (SD)		
		A	B	C	D	PER	UND	REG
Law and Economics (298; 34.9%)	Business Administration (298; 34.9%)	3.3 (0.777)	3.8 (0.867)	3.2 (0.809)	3.4 (0.752)	3.6 (0.792)	3.5 (0.750)	3.5 (0.859)
Humanities and Social Sciences (276; 32.4%)	Audiovisual Communication (149; 17.5%)	2.4 (0.962)	3.7 (0.950)	3.5 (0.860)	3.7 (0.729)	3.6 (0.741)	3.3 (0.777)	3.3 (0.909)
	Advertising and Public Relations (127; 14.9%)	2.5 (0.878)	3.7 (1.020)	3.7 (0.950)	3.7 (0.717)	3.7 (0.934)	3.2 (0.840)	3.4 (0.904)

[CONTINÚA EN LA PÁGINA SIGUIENTE]

FACULTY (N; %)	DEGREES (N; %)	LEARNING STYLES M (SD)				EMOTIONAL INTELLIGENCE M (SD)		
		A	B	C	D	PER	UND	REG
Humanities and Social Sciences (276; 32.4%)	Faculty Total	2.4 (0.924)	3.7 (0.981)	3.6 (0.904)	3.7 (0.725)	3.6 (0.835)	3.2 (0.806)	3.4 (0.906)
Experimental Sciences (279; 32.7%)	Agrifood and Rural Engineering (57; 6.7%)	3.8 (0.675)	3.8 (0.932)	3.4 (0.831)	3.7 (0.634)	3.7 (0.746)	3.5 (0.745)	3.7 (0.855)
	Electrical Engineering (44; 5.2%)	3.7 (0.641)	3.6 (1.035)	3.0 (1.130)	3.4 (0.766)	3.2 (1.105)	3.4 (0.902)	3.4 (0.851)
	Mechanical Engineering (66; 7.7%)	3.8 (0.925)	3.2 (1.038)	2.9 (1.060)	3.4 (0.651)	3.0 (1.086)	3.1 (0.996)	3.3 (0.913)
	Chemical Engineering (57; 6.7%)	3.8 (0.870)	3.5 (1.217)	2.9 (1.183)	3.6 (0.891)	3.2 (1.055)	3.2 (1.014)	3.1 (1.041)
	Industrial Technology Engineering (55; 6.4%)	3.6 (0.782)	3.4 (1.090)	3.0 (1.101)	3.4 (0.797)	3.3 (1.137)	2.9 (0.913)	3.2 (1.090)
	Faculty Total	3.7 (0.796)	3.5 (1.091)	3.0 (1.071)	3.5 (0.752)	3.2 (1.052)	3.2 (0.942)	3.3 (0.967)
Sample Total		3.1 (0.996)	3.7 (0.989)	3.3 (0.958)	3.5 (0.752)	3.5 (0.915)	3.3 (0.850)	3.4 (0.915)

Note: A = Quadrant A; B = Quadrant B; C = Quadrant C; D = Quadrant D; PER = Emotional perception; UND = Emotional understanding; REG = Emotional regulation

The chi-square test was carried out to verify the equivalence in the groups of male and female students and thus rule out any association of the variable gender with the studied variables. Results of this test are shown in Table 2.

Table 2: Summary of the Chi-square test regarding gender factor (α=0.05)

FACTOR	VALUE	DF	SIGNIFICATION
Quadrant A	11.007	8	0.201
Quadrant B	5.064	8	0.751
Quadrant B	4.371	8	0.822
Quadrant B	8.972	8	0.345
Emotional perception	11.019	16	0.808
Emotional understanding	10.716	16	0.827
Emotional regulation	4.071	16	0.999

Measurement Instruments

The constructs analysed in the study were measured using two five-point Likert diagnosis instruments from a broad scientific corpus of previous research in teaching contexts.

First, we used a shorter adaptation of Whole Brain Theory Diagnosis, Jiménez's (2006) measurement instrument based on the Herrmann Brain Dominance Instrument (HBDI) (Herrmann, 1989) to measure the dominant learning styles among students. This is an eight-item self-report instrument (see Table 3) that gathers, on a five-point Likert scale (1 = completely disagree; 5 = completely agree), respondents' opinions of their own degree of performance in each of the aspects or activities associated with the four brain quadrants (2 items associated with each quadrant).

Second, as with the conceptualisation of the EI construct, there appears to be no general consensus on which measurement instrument is the most suitable to assess it (Antonio-Agirre, Esnaola and Rodríguez-Fernández, 2017). Several options have been proposed over the years including, among others, the *Emotional Quotient Inventory* (EQ-i; Bar-On, 1997), the *Trait Emotional Intelligence Questionnaire* (TEIQue; Petrides and Furnham, 2003), the *Multifactor Emotional Intelligence Scale* (MEIS, Mayer, Caruso and Salovey, 1999), and the *Mayer-Salovey Cruso Emotional Intelligence Test* (MSCEIT, 1999, 2001). Without wishing to detract from the merits of any of the other proposals, and based on the notion that "each instrument is valid, depending on the purpose" (Antonio-Agirre, Esnaola and Rodríguez-Fernández, 2017; Escoda, 2016; Extremera, Fernández-Berrocal, Mestre and Guil, 2004), the students' EI was measured using a simplified adaptation of the most widely used scale to assess the concept in psychological and educational research in both Spain and Latin America (Antonio-Aguirre, Esnaola and Rodríguez-Fernández, 2017; Fernández-Berrocal and Extremera, 2005; Salove, Stroud, Woolery and Epel, 2002): the *Spanish Trait Meta-Mood Scale* (TMMS-24; Fernández-Berrocal, Alcaide, Domínguez, Femández-McNally, Ramos and Ravira,1998, 2004; based on Salovey Mayer, Goldman, Turvey and Palfai's original scale, 1995). As shown in Table 4, this is a meta-knowledge trait scale with 12 items assessed on a five-point Likert scale to assess level of agreement with the items (1 = completely disagree; 5 = completely agree), which yields the perceived emotional intelligence rate through three factors: perception, understanding and regulation of one's own emotions (four items per factor).

Although neither of these diagnostic instruments was initially conceived as part of causal research methodology, such as the structural equations models (SEM) technique used in this study, several factors justify its application in this new methodological context.

First, in self-report data collection processes this kind of instrument guarantees ease of understanding and administration for students, in terms of both time and form. Secondly, both instruments reflect conceptualisations associated with basic learning and emotional skills. Third, because they are designed to encourage introspection, they allow researchers to assess underlying processes that are not easily measured with alternatives such as skill tasks.

As mentioned earlier in the article, we used the shorter versions of both scales since we were looking for a general medium-length questionnaire that would not interfere with levels of concentration and sincerity in the students' responses. Additionally, SEM does not require a large number of indicators for each latent variable to function optimally. This also helps to prevent a major problem in fieldwork among students, namely, potential bias due to survey fatigue during completion (Fernández-Berrocal and Extremera, 2005).

Validity and Scale Reliability

The scales were refined by confirmatory factor analysis for SEM using the statistical program EQS 6.1. This methodology allows researchers to test theoretical models that contain both the latent variables representing a given theoretical concept, and the indicators designed to measure them, making this method an essential tool to validate measurement scales (Steenkamp and Van Trijp, 1991). The parameters were estimated using the robust maximum likelihood approach.

We applied the following model development strategy (Hair, Black, Babin and Anderson, 2009). Based on Jöreskog and Sörbom's (1993) recommendations, we first examined the estimation parameters. The indicators satisfied the strong convergence condition with individual standardised coefficients ( ) above 0.6 and a mean factor loading value higher than 0.7 (Bagozzi and Youjae, 1988; Steenkamp and Van Trijp, 1991; Hair et al., 2009). We then confirmed that the weak convergence condition was satisfied by analysing the significance of the factor regression coefficients compared to their corresponding latent variable (Steenkamp and Van Trijp, 1991). To this end we reviewed the minimum requirement of Student's t statistic ($t > 2.58$; $P = 0.01$). Finally, the main goodness-of-fit indices were obtained. The fit of the conceptual model to the empirical data was studied with the following statistics: normed 2, normed fit index (NFI), non-normed fit index (NNFI), incremental fit index (IFI), comparative fit index (CFI), goodness-of-fit index (GFI), root mean square residual (RMR) and root mean square of approximation (RMSEA).

Various tests were then performed to ensure that the refinement process had not affected the scales' reliability: the reliability coefficient analysis to assess the internal consistency using Cronbach's   (Nunnally, 1979), and the composite reliability of the construct (FC). In both cases, values higher than 0.7 were considered acceptable (Fornell and Lacker, 1981; Hair et al., 2009). The variance extracted (VE) was also analysed, the minimum acceptable value being 0.5 (Fornell and Lacker, 1981; Hair et al., 2009). The results of these tests are reported in Tables 3 and 4.

Table 3. Summary of the factor analyses and the validity and reliability analyses of the measurement scales for the students' learning styles

Quadrant A (α=0.783; FC=0.79; VE=0.66)	λ	t value
A.1 - I think the best way of solving a problem is to be analytical and rational rather than following instinct.	0.882	14.016*
A.2 - I am capable of understanding and handling numbers for a given purpose.	0.731	12.635*
Quadrant B (α=0.758; FC=0.80; VE=0.67)	λ	t value
B.1 - I prioritise planning and organisation in my activities.	0.625	5.460*
B.2 - For me it is important to have a place for everything and everything in its place.	0.977	5.610*
Quadrant C (α=0.700; FC=0.70; VE=0.50)	λ	t value
C.1 - On many occasions the emotional takes precedence over the logical and the rational in my decisions.	0.698	12.630*
C.2 - I am capable of developing and maintaining good communication with different types of people.	0.768	12.888*

[CONTINÚA EN LA PÁGINA SIGUIENTE]

Quadrant D (α=0.728; FC=0.70; VE=0.54)	λ	t value
D.1 - I am capable of reasoning in an advanced and creative manner and am able to acquire, modify and retain knowledge.	0.783	6.231*
D.2 - I produce new ideas and innovations in my work.	0.681	6.158*
χ2/df=1.523; NFI=0.981; NNFI=0.973; IFI=0.989; CFI= 0.989; GFI=0.992; RMR=0.024; RMSEA=0.040		

Note: *p<0.01

Table 4. Summary of the factor analyses and the validity and reliability analyses of the measurement scales for the students' emotional intelligence

Perception (α=0.881; FC=0.88; VE=0.65)	λ	t value
PERCE.1 - I usually care a lot about what I feel.	0.837	7.014*
PERCE.2 - I usually spend time thinking about my emotions.	0.865	6.759*
PERCE.3 - I often think about my feelings.	0.614	7.597*
PERCE.4 - I pay a lot of attention to how I feel.	0.878	11.581*
Understanding (α=0.853; FC=0.85; VE=0.59)	λ	t value
UNDERSTAND.1 - I am very clear about my feelings.	0.766	23.307*
UNDERSTAND.2 - I can normally define my feelings.	0.815	25.586*
UNDERSTAND.3 - I almost always know how I am feeling.	0.802	25.597*
UNDERSTAND.4 - I can always tell how I feel.	0.674	20.753*
Regulation (α=0.863; FC=0.87; VE=0.64)	λ	t value
REGUL.1 - Even if I'm feeling sad, I usually have an optimistic outlook.	0.763	24.753*
REGUL.2 - Even if I'm feeling bad, I try to think about pleasant things.	0.924	32.870*
REGUL.3 - When I get upset, I remind myself of all the pleasures in life.	0.681	21.792*
REGUL.4 - I try to think positive thoughts even if I'm feeling upset.	0.803	26.612*
χ2/df=1.986; NFI=0.978; NNFI=0.963; IFI=0.983; CFI= 0.983; GFI=0.977; RMR=0.038; RMSEA=0.060		

Note: *p<0.01

Finally, convergent and discriminant validity were analysed. The estimated value of the correlations between the dimensions of the scales was high and significant, thus confirming convergent validity. Discriminant validity of the constructs is reported in Table 5, evaluated by means of variance extracted (VE). When the square root of the VE between each pair of factors is higher than the estimated correlation between those factors, as in our case, discriminant validity is confirmed (Fornell and Larcker, 1981).

Table 5. Discriminant validity of the measurement scales

	1	2	3	4	5	6	7
(1) Quadrant A	0.81						
(2) Quadrant B	0.03*	0.82					
(3) Quadrant C	0.31*	0.17*	0.73				
(4) Quadrant D	0.02*	0.06*	0.13*	0.73			
(5) Emotional perception	0.16*	0.17*	0.59*	0.20*	0.81		
(6) Emotional understanding	0.01*	0.13*	0.04*	0.21*	0.25*	0.77	
(7) Emotional regulation	0.01*	0.07*	0.04*	0.21*	0.12*	0.46*	0.80

Note: the estimated correlation between the factors is shown below the diagonal; the square root of the VE is on the diagonal; * p<.01

The analyses undertaken with this methodology guarantee consistency of the model with its theoretical proposals for each of the scales used, based on reliable and valid scales for empirical use in the fieldwork.

Additionally non-response bias was analysed using a means analysis for independent samples with SPSS 18.0 for each of the items in the refined scales. The first 50 responses were compared with the last 50. In all cases equal variance was assumed, therefore confirming the absence of non-response bias (Armstrong and Overton, 1977).

Finally, possible common method variance bias was controlled for with Harman's (1976) test, which concluded that the bias resulting from the method used was not a problem for the validity of the results on testing subsequent hypotheses (Podsakoff, MacKenzie, Lee and Podsakoff, 2003; Friedrich, Byre and Mumford, 2009).

Results

As with the scale validations, the model was tested with SEM (Hair et al., 2009) using the EQS 6.1 program. These models have proved useful when the research objective is to uncover the causal contributions of one variable on another in a non-experimental situation (Jöreskog and Sörbom, 1993). Additionally, unlike techniques such as multiple regression, factorial analysis, and multivariate analysis of variance, which only allow one relationship to be examined at the same time, analysis with structural equations models (SEM) can explore a series of dependence relationships simultaneously (Hair, Black, Babin and Anderson, 2009). Results are displayed in Table 6.

Table 6. Summary of the results of the structural models

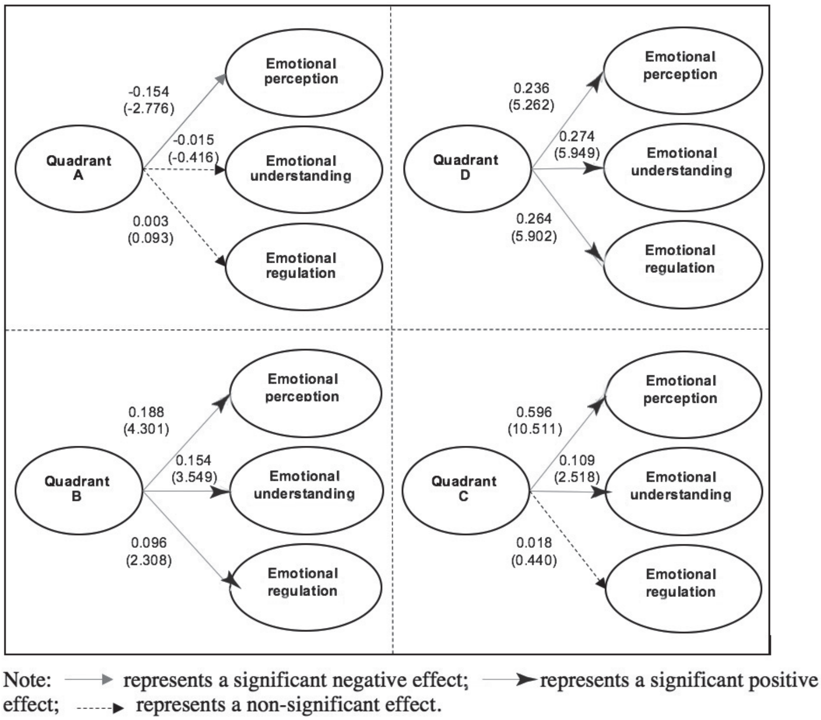
RELATION		PARAMETER	T
A.1	Quadrant A → Emotional perception	-0.154	-2.776**
A.2	Quadrant A → Emotional understanding	-0.015	-0.416
A.3	Quadrant A → Emotional regulation	0.003	0.093
χ2/df=3.295; NFI=0.964; NNFI=0.954; IFI=0.973; CFI= 0.973; GFI=0.965; RMR=0.043; RMSEA=0.059			
B.1	Quadrant B → Emotional perception	0.188	4.301**
B.2	Quadrant B → Emotional understanding	0.154	3.549**
B.3	Quadrant B → Emotional regulation	0.096	2.308*
χ2/df=2.288; NFI=0.976; NNFI=0.936; IFI=0.980; CFI= 0.980; GFI=0.976; RMR=0.035; RMSEA=0.070			
C.1	Quadrant C → Emotional perception	0.596	10.511**
C.2	Quadrant C → Emotional understanding	0.109	2.518*
C.3	Quadrant C → Emotional regulation	0.018	0.440
χ2/df=4.228; NFI=0.967; NNFI=0.927; IFI=0.972; CFI= 0.972; GFI=0.968; RMR=0.038; RMSEA=0.060			
D.1	Quadrant D → Emotional perception	0.236	5.262**
D.2	Quadrant D → Emotional understanding	0.274	5.949**
D.3	Quadrant D → Emotional regulation	0.264	5.902**
χ2/df=2.901; NFI=0.962; NNFI=0.961; IFI=0.973; CFI= 0.972; GFI=0.964; RMR=0.043; RMSEA=0.054			

Note: *p<0.05; **p<0.01

Figure 2 shows that all the proposed learning style relations associated with quadrants B and D are positive and significant (relations B.1, B.2, B.3 and D.1, D.2, D.3). Learning style relations associated with quadrant C (relations C.1, C.2) are also positive and significant, except relation C.3. The two research hypotheses are therefore confirmed.

The results show, first, that learning styles based on mixed dominances (particularly through intensive learning in competencies from quadrants B and D) positively influence the development of the component functions of students' emotional intelligence (H1). Second, the results confirm that learning styles associated with the right hemisphere contribute more to developing students' emotional intelligence (H2). Indeed, the learning style based on quadrant A is the only one with no positive influence on the development of functions generating emotional intelligence; moreover, it has a significantly negative influence with regard to the emotional perception function (relation A.1).

Figure 2. Summary of the model of effects



Note: represents a significant negative effect; represents a significant positive effect; represents a non-significant effect

Discussion

Over the last decades, the literature has reflected a steady interest in determining students' learning styles, which in turn have proved useful for designing training curricula (Cárdenas, Conde-González and Perales, 2015) aiming to respond to student interests and motivations through contextualised and meaningful learning. Achieving this goal appears to be conditioned by the creative construction of favourable environments that take into account personal styles and preferences, and where students are the protagonists in their own training process.

In parallel, there is a widespread demand for the university community to respond not only to students' motivation but also to social and business needs. Employers are increasingly looking for university graduates with the appropriate technical and professional skills, but also with well-developed social and emotional skills. In this context, the present study proposes an innovative theoretical model that relates learning styles according to the postulates of the whole brain theory with the development of these social and emotional skills proposed by EI. The principal objective of the study is to offer a set of didactic proposals on how best to approach the teaching of university students, taking into account their learning styles, thus leading to a general reflection on the most appropriate teaching methods to provide the most comprehensive education possible and unlock the full potential of students' abilities.

Additionally, the rapid development of neuroscience suggests we should consider that learning styles are conditioned by brain dominance and by the degree curricula. Thus, Segarra, Estrada and Monferrer (2015) and Estrada, Monferrer and Moliner (2016) highlight the need to review the curricula design in university degrees to promote learning styles with certain brain dominance over others. One example is the engineering degree programmes associated with developing competencies related to quadrants A and B, which contribute little to the competences developed in quadrants D and C; this situation is reversed in programmes designed for humanities and social science degrees. We can infer, therefore, that the brain dominance used in the learning style assumes that degrees apply the aptitudes determining good development of EI in different ways. On this point the confirmation of our first hypothesis endorses the idea that students need to be trained to use a learning style that allows for mixed dominances, which in turn, will help develop their EI. Gómez (2004) and Ferrer, Villalobos, Morón, Montoya and Vera (2014) hypothesised that when students are trained to use the four brain quadrants, education becomes more effective and students' academic performance notably improves. Indeed, Herrmann (1989) and Herrmann and Herrmann-Nehdi (2015) point out that any task, especially complicated tasks, requires both hemispheres, thus implying that all four emotional competencies should be developed (Mayer and Salovey, 1997). Salas's (2008) study found that students' development of the four brain quadrants requires a favourable environment for the process. Modifying this environment frequently depends on the teachers' teaching-learning style (Estupiñán, Cherrez, Intriago and Torres, 2016).

Additionally, the results obtained from testing and confirming the second research hypothesis lend support to findings by Herrmann (1989) and Herrmann and Herrmann-Nehdi (2015) as our results confirm the relationships between the left hemisphere and cognition, and the right hemisphere and emotion. Learning styles associated with the right hemisphere contribute more to developing students' emotional intelligence. However, quadrant C is positively associated with the emotional competencies of perception and understanding, but not regulation. This is because the individuals' holistic profile poses certain problems for controlling and regulating the tangle of emotions and feelings facing their learning style. We therefore recommend teachers focus on training activities to develop the control competence. In contrast, learning styles associated with the left hemisphere revealed less development of emotional competencies. Although dominance in quadrant B yields positive results in emotional intelligence, quadrant A provides no significant results in understanding and regulation competencies, and is negative in the relation with emotional perception. The reason for these results is that it is essentially a rational learning style that grants little relevance to emotions and their management.

Schmidt (2002), an author critical of EI in the world of work, suggests EI may be considered as one of the constructs related to individual differences that may be useful for constructing successful performance models. This author argues that EI is particularly useful for successful performance in professions involving interaction with other people and that often place employees in highly emotionally charged situations. It is therefore crucial to train tomorrow's professionals using learning styles that enable their EI to develop and that can prepare them to make better use of cognitive capabilities for processing emotional information, thus becoming efficient professionals and healthy citizens (Lopes, Brackett, Nezlek, Schütz, Sellin and Salovey, 2006; Molero, Pantoja-Vallejo and Galiano-Carrión, 2017; Sáez, Lavega, Mateu and Rovira, 2014). In this vein, and coinciding with Rojas et al. (2006), one of the lessons that educators can learn from the findings of this study is that instruction becomes more effective, the more the content is presented not only in the traditional verbal modality (stimulating the left hemisphere, quadrants A and B), but also in the non-verbal or representational modality (graphics, images, pictures, etc.), which help to stimulate the right hemisphere (quadrants C and D). This finding leads us to propose a mixed teaching strategy that combines sequential and linear techniques with other approaches that allow students to see patterns by making use of visual and spatial thought, and deal with the whole as well as the parts. The following teaching strategies can be used to this effect: role-plays, direct experience, practical cases, multi-sensory learning, music, art, comics, cinema, etc. In addition, the results should prompt reflection on the current curricula of many degrees, which are frequently designed to encourage certain dominance styles to the detriment of others. Finally, we propose the development of training programmes for educators to enable them to develop mixed methodologies that stimulate their students' holistic development.

The present study has certain limitations. First, the sample was recruited in just one university, and it would therefore be useful to repeat the study in other universities and secondary schools in order to compare results. Second, although the TMMS-24 measurement instrument has been widely used in the Spanish and Latin American context, its current use is perhaps excluding other alternative options.

Finally, it should be noted that during this academic year, educators from the subjects and degrees involved in the study have redesigned the methodologies they use by incorporating mixed learning strategies aimed to develop learning styles in universities with dominances in most of the brain's quadrants, thus maximising students' technical and emotional capabilities to the full. We are currently analysing the data obtained and hope that the outcomes will allow us to continue exploring this research line further. We are also working to open up new channels for collaboration with other universities and secondary schools in order to replicate the model.

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