KURAM VE UYGULAMADA EĞİTİM BİLİMLERİ EDUCATIONAL SCIENCES: THEORY & PRACTICE

Received: March 9, 2015
Revision received: April 4, 2016
Accepted: June 26, 2016
OnlineFirst: October 5, 2016

www.estp.com.tr
DOI 10.12738/estp.2016.6.0084 • December 2016 • 16(6) • 2057–2086

Research Article

A Meta-Analysis on the Effect of Instructional Designs based on the Learning Styles Models on Academic Achievement, Attitude and Retention*

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Abstract

The purpose of this study is to calculate the effect size, by running a meta-analysis, of the experimental studies carried out in Turkey between 2004 and 2014 that investigate the effect of learning styles on academic achievement, attitude, retention, and to define whether the academic achievement shows a significant difference in terms of learning styles model, experimental design and course type. For this purpose, a meta-analytical review method was employed to combine the outcome of the independent experimental studies. The studies included in this review were collected from CoHE National Thesis Archive (2015), ULAKBIM (2015), Google Academic (2015), ERIC (2015) and EBSCO (2015) databases. As a result of the searching process, 402 studies were assessed according to the inclusion criteria and 30 experimental studies were included in this study. Cohen's d coefficient was calculated for the effect size in this study. Because there was a high amount of heterogeneity ($Q > x^2$, $p < .05$) among the effect sizes of the studies, the common effect size was calculated according to the random effect model. As a result of meta-analysis, it was determined that the instructional designs based on the learning styles model had a large effect on the academic achievement (d = 1.029), attitude (d = 1.113) and retention (d = 1.290). Moreover, the academic achievement did not show any significant difference according to learning style model, course type and experimental design.

Keywords

Learning styles models • Academic achievement • Attitude • Retention • Meta-analysis

* Some parts of this study were presented at the "The Third International Congress on Curriculum and Instruction."

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Citation: Kanadlı, S. (2016). A meta-analysis on the effect of instructional designs based on the learning styles models on academic achievement, attitude and retention. *Educational Sciences: Theory & Practice*, *16*, 2057–2086.

Today's curriculums focus on students' individual differences with the influence of the constructivist approach. When teaching a lesson, teachers are also expected to organize learning experiences by paying attention to these students' individual differences. One of the students' individual differences is the learning style and learning modality developing in parallel with it. Learning style commonly means the preference of the students in respect to receiving and processing information. Keefe (1979) defined learning style as 'characteristics cognitive, affective and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with and respond to the learning environment'. With references to this definition, one of the major characteristics of learning style is that it affects how students perceive information, construct it in their mind and make sense of their environment accordingly. Another major characteristic of learning style is that it develops based on experiences and not genetic traits (BECTA, 2005). In other words, the preferred learning style may change over time rather than remaining stable, and is independent of both students' abilities and content (Reiner & Willingham, 2010). Learning styles have mainly focused on different types of information and processing them in various ways (Garcia, Amandi, Schiaffino, & Campo 2007). Consequently, there are many types of learning styles models in the literature and many instruments developed according to these models. Examples of the most popular learning styles models in literature are the Perceptual Model, the Kolb Learning Styles Model, the Dunn and Dunn Learning Styles Model, the 4MAT System, the Honey & Mumford Learning Styles Model and the Grasha and Riechman Learning Styles Model. Although these models resemble each other in many ways, there are many differences among them that emanate from their definitions.

For instance, the Perceptual Learning Style Model classifies students according to which sensory receivers (visual, auditory, kinaesthetic) they prefer most when perceiving information. Kolb (1984) stated in his learning styles model that people perceive information through thinking and feeling (abstract conceptualization and concrete experience) and process it through doing and watching (active experimentation and reflective observation). The Dunn and Dunn Learning Styles Model identifies five stimuli sources (environmental, emotional, sociological, physiological and psychological) that affect students' learning and 21 learning style elements across these five stimuli sources (Dunn, 2000). The 4MAT Model is based on Kolb's Experiential Learning Model and identifies learning in terms of how people perceive (thinking-sensing) and process (doing-watching) information (McCharty, 1990). The Honey and Mumford Learning Styles Model renames Kolb's learning cycle according to individuals' experiences of problem solving and decision making (activist, theorist, pragmatist, reflector) (Honey & Mumford, 2006). The Grasha and Riechman Learning Styles Model focuses on students' attitudes and feelings toward learning, classroom activities and interaction with teachers and peers (Uzun & Şentürk, 2008).

Various scales designed according to learning style models are used to determine individuals' learning style. For example, in order to determine perceptual learning styles (visual, auditory, kinaesthetic), various activities are given item by item, and the dominant learning style is discovered depending upon whether the individual prefers these activities or not. The Kolb Learning Style Inventory, consisting of 12 items, is used to determine learning style according to Kolb Learning Styles Model. In this inventory, four activities are given under each item and the individual is asked to grade these between 1 and 4. The scores of the individual's learning mode (concrete experience, reflective observation, abstract conceptualization, active experimentation) on the four-stage cycle of learning is calculated (Aşkar & Akkoyunlu, 1993). After that, the concrete experience score is subtracted from abstract conceptualization score, and the reflective observation score is subtracted from active experimentation score. The individual's learning style (diverging, assimilating, converging, accommodating) is found by intersecting the obtained results on the coordinate plane developed by Kolb (1984). In the 4MAT System, the individual's modes of perceiving (concrete experience, abstract conceptualization) and processing (reflective observation, active experimentation) information are identified by using the Kolb Learning Style Inventory, and then the profile of learning style (imaginative, analytic, common sense, dynamic) is discovered by combining the modes of perceiving and processing (McCharty, 1990). In the Dunn and Dunn Learning Styles Model, a learning style scale, consisting of 104 items and a five-point Likert-type scale is utilized. Based on the scores obtained from this scale, the dominant learning style preference is identified in environmental, emotional, sociological, physiological and psychological elements (Coffield, Moseley, Hall, & Ecclestone, 2004). In the Honey and Mumford Learning Styles Model, a learning style questionnaire is used, consisting of 80 items. In this questionnaire the individuals identify their learning style by summing the items that they select according to their preferences (Honey & Mumford, 2006).

Despite different points of view regarding definition and categorization of learning style, the learning styles models examined above are based on the premise that all people can be classified according to their learning styles (Coffield et al., 2004). Most of these learning styles classifications are type theories based on the works of C.G. Jung, who classified individuals according to personality type through a Myers-Briggs Type Indicator for the first time in the 1940s (Pashler, McDaniel, Rohrer, & Bjork, 2008). At that time, personality theories, information processing styles of cognitive style research and aptitude treatment interaction had an influence on the emergence of most of the learning style theories and their popularization (Keefe & Ferrell, 1990). It can also be said that the theories of learning styles have remained popular to this day. According to Pashler et al. (2008), the first reason for the popularity of these theories is that the approaches of learning styles have success in enhancing the teaching–learning environment. The second reason is that these approaches see individuals as unique and assert that if the instruction is tailored to the individuals' learning styles then everyone has the potential to learn effectively. The third reason is that they take the responsibility for students' failure in school upon themselves and attribute it to the quality of instruction.

For these reasons, when the literature about the learning styles models above is reviewed, these models can be seen to have been studied heavily and in terms of different variables (especially academic achievement, attitude and retention). There are many studies in the literature designed according to explanatory, relational and experimental design. Relational studies discovered a significant relationship between learning styles and academic achievement in any course or attitudes toward a course (Cano, 1999; Çakıroğlu, 2014; Çalışkan & Kılınç, 2012; Güven, 2008; Jahanbakhsh, 2012). Conversely, there are also studies revealing that there is no significant relationship between learning styles and academic achievement or attitudes (Altun & Cakan, 2006; Bahar, Özen, & Gülaçtı, 2009; Bölükbaş, 2007; Gappi, 2013; Warn, 2009). Similarly, in experimental studies it was determined that learning environments tailored to students' learning styles, compared to a traditional environment, had the following effects: a) raising students' academic achievement (Aydıntan, Şahin, & Uysal, 2012; Baş & Beyhan, 2013; Bozkurt & Aydoğdu, 2009; Constantinidou & Baker, 2002; Demir & Usta, 2011; Jackson, 2001; Kaf Hasırcı, 2005; Özgen & Alkan, 2014; Tie & Umar, 2010; Tsai, 2004; Usta, Bodur, Yağız, & Sünbül, 2011); b) making their learning more persistent (Baş & Beyhan, 2013; Cengizhan, 2007; Güven, 2007; Jakson, 2001; Tsai, 2004; Yazıcılar & Güven, 2009; Yılmaz & Dinçol Özgür, 2012); and c) improving their attitudes toward courses (Baş & Beyhan, 2013; Boström, 2011; Bozkurt & Aydoğdu, 2009; Elçi, 2008; Evin Gencel, 2008; Güven, 2007; Jackson, 2001; Usta et al., 2011). Conversely, there have also been studies that discovered no meaningful effect of learning styles on a) academic achievement (Ateş & Çataloğlu, 2007; Çolak, 2013; Mahiroğlu & Bayır, 2009; Yılmaz Soylu & Akkoyunlu, 2002), b) retention (Dyer & Osborne, 1999; Kaf Hasırcı, 2005; Mahiroğlu & Bayır, 2009), or c) attitudes (Özgen & Alkan, 2014; Yazıcılar & Güven, 2009).

There are also studies in the literature indicating the inadequacy of the experimental research conducted about the effectiveness of learning styles models. For example, Pashler et al. (2008) concluded in their literature review that there was not sufficient evidence for integrating learning styles into instruction. Likewise, Reiner and

Willingham (2010) argued in their article, "The Myth of Learning Style," that the main difference among learners resulted from their background knowledge, abilities and interests, but there was no reliable evidence that learning styles exist. In other words, there is no experimental evidence that if the teachers' mode of instruction matches the students' preferred learning styles then it can improve students' learning (raising their academic achievement) (Reiner & Willingham, 2010). As seen in the literature, among the individual studies conducted about the effectiveness of learning styles there are studies with conflicting results and others which argue that learning styles are the product of popular culture (Pashler et al., 2008) and there is not sufficient evidence that learning styles are exist.

Four meta-analytical studies investigating the effect of learning styles on academic achievement were identified. The first of these is the study conducted by Kavale and Fortness (1987) to determine the effect on academic achievement of learning environments designed according to Perceptual Learning Styles. Kavale and Fortness (1987), as a result of the meta-analysis of 39 experimental studies, calculated the effect size as 0.14 (a small effect). The second study was conducted by Dunn, Griggs, Gorman, Olson, and Beasley (1995) in order to investigate the effect on academic achievement of courses designed according to the Dunn and Dunn Learning Styles. In this study, as a result of the meta-analysis of 42 experimental studies conducted in 1980–1990, the effect size was calculated as .755 (a large effect). The authors concluded that instruction tailored to students' learning styles could be useful for their academic achievement. The third study was carried out by Slemmer (2002) in order to examine the effect of learning styles on academic achievement in the technology enhanced learning environment. In this study, as a result of the meta-analysis of 48 experimental studies, the effect size was calculated as .13 (a small effect). The fourth study was conducted by Lovelace (2005) in order to investigate the effect on academic achievement and attitude of courses designed according to the Dunn and Dunn Learning Styles Model. In this study, as a result of the meta-analysis of 76 experimental studies conducted in 1980–2000, the effect size was calculated for academic achievement as .87 (large effect) and for attitude as .85 (large effect). As a result of this study, it was determined that Dunn and Dunn Learning Styles Model had a powerful effect on academic achievement and attitude.

The meta-analytical studies summarized above were conducted to determine the effect of a single learning style model on academic achievement; however, no studies calculating the common effect size by combining effect sizes of all learning styles models and determining the most effective learning style model could be found in the literature. Likewise, no studies were found in the national literature that investigated the effect of learning styles models on academic achievement, attitudes and retention.

On the contrary, besides individual studies in the national literature, which indicated that instruction based on learning styles has effects on academic achievement, attitude and retention, there are some other individual studies that show no significant effect on academic achievement, attitude and retention, which has created the need to make a synthesis by combining these studies through meta-analytic review method. Consequently, the purpose of this study was to calculate the effect size by performing meta-analysis of the experimental studies, carried out in Turkey in 2004–2014, that investigate the effect of learning styles on academic achievement, attitude and retention, and to determine whether the academic achievement shows a meaningful difference in terms of learning style model, experimental design and course type. Thus, we aim to give both conceptual and procedural directions by making suggestions regarding studies which will be conducted on learning styles in Turkey.

In this study, while the dependent variables are academic achievement, attitude and retention, the independent variables are the type of learning style model, the type of experimental design and course type. The effect of learning styles models on academic achievement was investigated in terms of three categorical moderators: the type of learning style model, the type of experimental design and course type.

Learning Styles Models and Academic Achievement

Academic achievement is defined as the level of acquisition of the course attainments as a result of learning experiences that the students undergo in any discipline courses (science, mathematics, language, social science). It can be said that the final aim of the learning experiences provided in any course is to raise academic achievement by improving students' knowledge and skills. Studies indicate that the learning styles models have a significant effect on academic achievement (Constantinidou & Baker, 2002; Jackson, 2001). In national literature, when the experimental studies relating to learning styles were reviewed, it was found that experimental studies were conducted mostly according to the following models: McCharty's 4MAT Model (Aktaş & Bilgin, 2012; Aydıntan et al., 2012; Ergin & Atasoy, 2013; Dikkartın Övez, 2012; Mutlu & Okur, 2012; Öztürk, 2007); the Perceptual Learning Style Model (Babacan & Gökbudak, 2011; Balcı, 2013; Önder, 2006, 2012; Usta et al., 2011); the Dunn and Dunn Learning Style Model (Bozkurt & Aydoğdu, 2009; İnal, 2013; Kaf Hasırcı, 2005); the Kolb Learning Style Model (Aslan, 2012; Evin Gencel, 2008; Özdemir & Dindar, 2013); and the Grasha-Reichman Learning Style Model (Alşan, 2009; Arı & Bayram, 2011; Karadeniz Bayarak & Bayram, 2012). These studies showed that learning styles were effective in raising academic achievement. This study aims to determine whether there is a significant difference among the effects of these models on academic achievement and to identify the most effective model. Therefore, the findings of this study should contribute to the literature and give new perspectives to the educators in the field.

Experimental Design and Academic Achievement

The second moderator is the type of experimental design. In the national literature, it was reported that quasi-experimental design (Aktaş & Bilgin, 2012; Balcı, 2013; Mutlu & Okur, 2012; Önder, 2012; Şeker & Yılmaz, 2010; Tatar & Dikici, 2009), true-experimental design (Aslan, 2012; Gökova, 2010; Günay Ermurat, 2008; Özdemir, 2009; Usta et al., 2011) and weak experimental design (Çolak, 2013; Gökalp, 2013; Uyangör & Dikkartın, 2009; Yılmaz Soylu & Akkoyunlu, 2002) were used in the studies investigating the effect of learning styles models on academic achievement. According to Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, and Demirel (2008), in weak experimental design the comparison is made in one group by applying pretest and posttest whereas in quasi-experimental design there are two groups—one treatment group and one control group selected by non-random method—and a between-group comparison is made. Unlike the quasi-experimental design, in true-experimental design, the treatment and control groups are randomly assigned. Whether there is a significant difference between assigning the treatment and control groups randomly or by matching, is considered important in terms of directing the experimental studies to be conducted henceforth.

Course Type and Academic Achievement

The third moderator is course type. In the national literature, the studies investigating the effect of learning styles models on academic achievement are mostly carried out in the following areas: science (Aktaş & Bilgin, 2012; Arı & Bayram, 2011; Ateş & Çataloğlu, 2007; Bozkurt & Aydoğdu, 2009; Mutlu, 2004; Usta et al., 2011); mathematics (Aydıntan et al., 2012; Dikkartın, 2006; Mutlu & Okur 2012); foreign languages (Balcı, 2013; Mahiroğlu & Bayır, 2009; Demirel, 2006; Güven, 2007); and social science (Evin Gencel, 2008; Kaf Hasırcı, 2005; Özbek, 2006; Şeker & Yılmaz, 2011). In these studies, it was determined that the learning styles models raised the academic achievement in different courses. However, the determination of what type of courses the learning styles models increase the academic achievement the most in is thought to contribute to the related literature.

Learning Styles Models and Retention

Retention is broadly defined as the knowledge and skills that the individuals obtained in a specific time, even if in the past, and the capacity of remembering the knowledge and presenting the skill when needed. In the national literature, in addition to the studies indicating that there is a significant rise in the level of retention when the students receive instruction in a classroom atmosphere according to learning styles models (Aydıntan et al., 2012; Baş & Beyhan, 2013; Güven, 2007; Özbek, 2006; Yazıcılar & Güven, 2009), that there are also some studies showing no significant rise in the level of retention (Kaf Hasırcı, 2005; Önder, 2012; Mahiroğlu & Bayır, 2009) and this has created the need for calculating the effect on retention of instruction practices based on learning styles models.

Learning Styles Models and Attitude

Attitude is a psychological tendency that is stated by evaluating an object, an event or a person with some degree of favour or disfavour (Eagly & Chaiken, 1993, p. 1). Because the individual's attitude toward an object, an event or a person can determine their behaviours (Üstüner, 2006), it is asserted that students' positive or negative attitudes affect their attention and positive feelings toward courses, and their achievement. When viewed from this aspect, the positive attitude toward a course is the desired condition. In the national literature, although some studies indicated a significant improvement in students' attitudes toward courses when they receive an instruction according to learning styles models (Ardıç, 2013; Baş & Bayhan, 2013; Bozkurt & Aydoğdu, 2009; Dikkartın, 2006; Elçi, 2008; Evin Gencel, 2008; Günay Ermurat, 2008; Mutlu, 2004; Özbek, 2006), there are also some studies showing no significant improvement in students' attitudes (Babacan & Gökbudak, 2011; Mutlu, 2004; Yazıcılar & Güven, 2009), and this has created the need for calculating the effect size of learning styles models upon attitude toward courses.

Purpose

The purpose of this study is to perform a meta-analysis of the experimental studies, carried out in Turkey between in 2004–2014, to investigate the effect of learning styles models on academic achievement, attitude, retention, and to define whether the academic achievement shows a significant difference in terms of learning styles model, experimental design and course type. For this purpose, the answers were sought for the following questions:

1. What is the effect of learning styles model on academic achievement?
2. Does the effect of learning styles models on academic achievement show a significant difference in terms of learning styles model, experimental design and course type?
3. What is the effect of learning styles models on attitude toward course and retention?

Method

A meta-analytical review method was employed to combine the outcome of the independent experimental studies. According to Cooper (1998), there are five stages in conducting a meta-analytical review: (i) formulating the problem, (ii) collecting the relevant studies, (iii) specifying inclusion and exclusion criteria, (iv) analyzing the findings of studies and interpreting the results and (v) presenting the findings obtained from synthesis of the studies (p.5). Based on these five stages, Card (2012) suggested that a meta-analytical review comprised of four sections: (i) Introduction: background of the studies, significant and purpose of the studies and problems, (ii) Method: literature search procedures, study inclusion and exclusion criteria, coding of study characteristics and data analytic strategy, (iii) Results: descriptive information, central tendencies and heterogeneity, moderator analyses, diagnostic analysis, (iv) Discussion: review of findings, explanations and implications of findings, limitations, conclusions.

Literature Search Procedure

The studies included in this review were collected from CoHE National Thesis Archive (2015), ULAKBIM (2015), Google Academic (2015), ERIC (2015) and EBSCO (2015) databases between June 2014 and January 2015. A final search was carried out in March 2016. These key words were entered for searching in the databases: "learning styl*", "learning mode," "learning modality," "learning preferences," "learning styles and academic achievement," "learning styles, experimental design," "Kolb," "Gregorc," "Myers-Briggs," "Dunn and Dunn," "4MAT," "McCarthy," "Honey and Mumford," "Grasha and Riechman," "Perceptual Learning Styles," "VAK," "VARK." The related literature was searched by examining the references of the collected studies. The necessary data were obtained by contacting the authors whose studies were restricted. As a result of these procedures, 489 studies conducted in Turkey were accessed. Because of the search criteria limiting the study years to 2004–2014, and the elimination of the duplicated studies, 402 studies were obtained.

Study Inclusion and Exclusion Criteria

In the context of this study, the specified criteria are as follows. (i) It must be an article, a thesis (masters or doctoral) or a proceeding employing experimental design and carried out in Turkey between the years of 2004 and 2014. Because the excess factors threaten the internal and external validity in weak experimental design, the studies employing this design was excluded in this study. (ii) Studies must investigate the effect of instruction tailored to students' learning styles on academic achievement, attitude and retention. (ii) Each study must have sample size (N), means score ($\bar{x}$), and standard deviation (SD). (iv) Studies must employ parametric tests (*t*-test, F-test or ANOVA).

According to the criteria above, 72 experimental studies conducted on learning styles were identified. Yet, 28 studies of those 72 experimental studies were excluded from this study because 13 studies used models (brain-based, problem based, advance organizer, Bayesian student modelling, etc.) other than learning style models, 12 studies were of weak experimental design, five studies used non-parametric tests and one master thesis was restricted. Nine studies were identified that were produced from theses. Because these studies were published, they coded as article. Finally, two proceedings were identified that were produced from theses and the findings were taken into consideration. Accordingly, 30 studies were identified that were suited to the criteria specified above.

The flowchart of the exclusion and inclusion processes of the studies obtained as a result of the literature search procedure was given below.

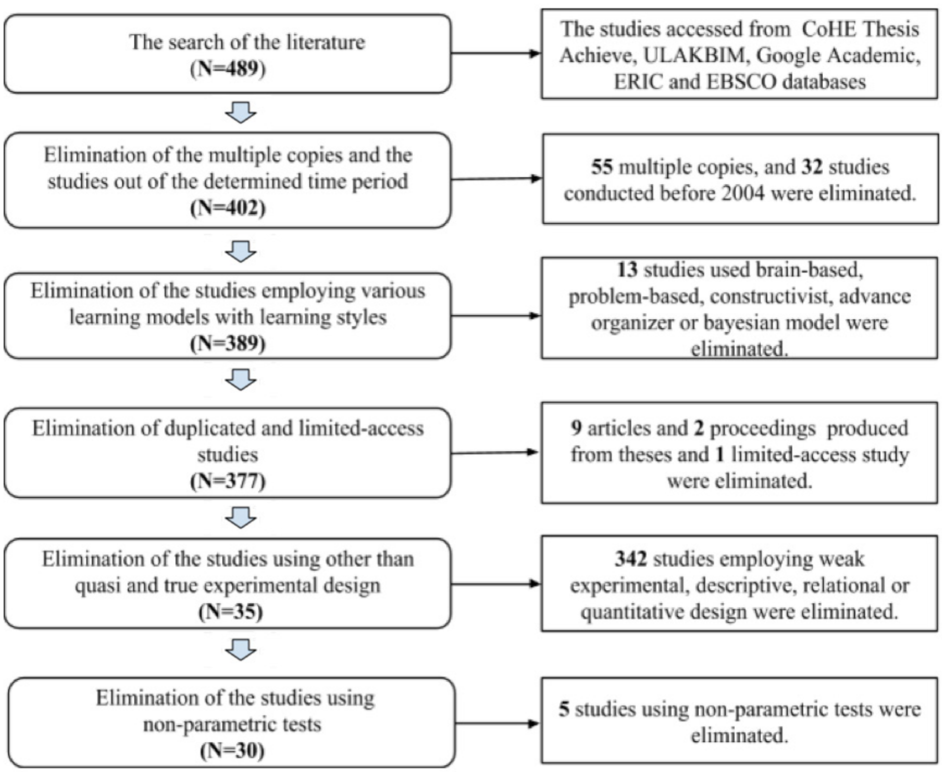

*Figure 1***.** The flowchart of literature search and the procedure of including the studies.

Coding of Study Characteristics

The studies matching the inclusion and exclusion criteria were coded according to the author and the date, the type (master, doctoral theses) of the study, the type of learning styles model (Kolb, Dunn & Dunn, Myers & Brigs, 4MAT, Honey & Mumford, Grasha & Riechman, Perceptual Learning Styles, Brain Dominance, Felder-Solomon), experimental design (quasi-true-experimental) and course type. As the course types, science and technology, physics, chemistry and biology were coded in natural science; social studies, history and geography were coded in social science. Also, the sample size of the treatment and control group, their means of posttest (if there was not a significant difference between pretests of treatment and control groups) and their SDs were coded.

In order to evaluate coding reliability, 10 (33% of the studies) studies were randomly selected and given to another coder and the intercoder reliability (agreement rate) was calculated by comparing the codes assigned by two coders. In order to calculate the agreement rate, the number of agreed codes was divided by the number of total codes (Card, 2012, p. 76). For reasonable reliability, the agreement rate should be more than 80 percent (Miles & Huberman, 1994). As a result of the codes assigned by the two coders, intercoder reliability was calculated as 100 percent.

Data Analytic Strategy

In meta-analysis, the effect sizes of the studies are combined according to two types of models: Fixed Effect and Random Effect Models. A test for homogeneity (or heterogeneity) is first performed to decide which model will be used to combine the effect sizes of the studies. Heterogeneity tests examine whether the observed variance in effect sizes is significantly different from expected variance due to sampling error (Cooper, 2010, p. 185). In order to determine this, Q-value or the significance level of heterogeneity test is examined. If the heterogeneity test is significant ($p < .05$) or the Q-value is bigger than the χ^2-value in the table (the value corresponding to the degree of freedom), the studies are heterogeneous; conversely, if the heterogeneity test is not significant ($p > .05$) or the Q-value is smaller than the χ^2-value in the table, the studies are homogeneous (Dinçer, 2014, p. 47). Although it indicates whether the effect sizes of the studies are heterogeneous, Q-value does not reveal the amount of the heterogeneity (Card, 2011, p. 118). For this purpose, the I^2 index is used. The I^2 index is a proportion of total variation in the estimates of effect size because of heterogeneity among studies (Higgins & Thompson, 2002). I^2 index is interpreted as follows, although it is not appropriate for all circumstances: a "low" heterogeneity is 25%, a "moderate" heterogeneity is 50% and a "high" heterogeneity is 75% (Higgins, Thompson, Deeks, & Altman, 2003).

In this review, Cohen's d (standardized mean difference) was used for calculating effect size. The standardized mean difference is more suitable for combining findings of studies if different studies use different instruments, and is calculated by dividing the mean difference in each study by that study's SD (Borenstein, Hedges, Higgins, & Rothstein, 2009, p. 25). Cohen (1988) offered a rule for interpreting d value: .20 is a 'small' effect size, .50 is a 'medium' effect size and .80 is a 'large' effect size. But this rule is arbitrary and abstract. For this reason, Cooper (2010) developed a useful way of concretely interpreting d index, which indicates the effect of any experimental intervention on achievement (p. 2012). This is based on a metric associated with d index, which was called U_3 by Cohen (1988). U_3 expresses the percentage of units in the group with the lower mean exceeded by 50% of the scores in the group with the higher mean (Cooper, 2010, p. 212). In order to determine this, the table shows that the equivalent values for the d index and U_3 effect size metrics is used (Cohen, 1988, p. 22).

Categorical moderator analysis was performed in order to determine whether the common effect size of the learning styles on academic achievement shows a significant difference according to learning style model, type of study design and course type. Categorical moderator analysis compares between groups and within groups of studies by classifying the between-study heterogeneity according to the created groups (model type, design type and course type etc.) (Card, 2012, p. 199; Hedges, 1982). Here, while fixed effect model or random effect model is selected (if $p > .05$ fixed effect model, if $p < .05$ random effect model) according to the significance level of comparison within groups, whether the moderator is significant according to the significance level of comparison between groups was determined.

Lastly, the most important factor threatening the reliability of meta-analytical studies is publication bias. Publication bias results from the fact that the studies reporting relatively high effect size have a higher possibility of publication than those reporting lower effect size (Borenstein et al., 2009, p. 277). One of the most effective strategies for overcoming the publication bias is to include published and unpublished studies in meta-analysis (Pigott, 2012, p. 79) and to perform a categorical moderator analysis according to the status of studies publication (published and unpublished) (Card, 2012, p. 262). For this reason, in order to determine the existence of publication bias and to evaluate its effect on meta-analysis, moderator analysis and diagnostic analysis were performed in this study. For diagnostic analysis, Rosenthal's Fail-safe N and Egger's regression intercept tests were performed. CMA 2.0 software was used in data analysis.

Findings

Findings Relating to the Characteristics of the Studies

The total sample size included in this review was 2159. The treatment groups consisted of 1075 and the control groups consisted of 1084 students. The table below shows the frequency distribution of the studies by course type, study type, learning style model, experimental design and investigated variable.

Table 1
The Frequency Distribution of the Studies by Course Type, Study Type, Learning Style Model, Experimental Design and Investigated Variable

Variables	Frequency (f)	Percent (%)
1. Course type		
Science	9	30.0
Mathematics	7	23.3
Social science	6	20.0
English	5	16.7
Informatics	2	6.7
Music	1	3.3
2. Study type		
Thesis	16	53.3
Article	14	46.7
3. Learning Style Model		
Perceptual	13	43.3
4MAT	10	33.3
Kolb	2	6.7
Dunn & Dunn	3	10.1
Felder & Solomon	1	3.3
Brain Dominance	1	3.3
4. Experimental design		
Quasi-experimental	26	86.7
True-experimental	4	13.3
5. The investigated variable		
Achievement	29	58.0
Attitude	11	22.0
Retention	10	20.0

According to Table 1, in terms of course type, 30% (f = 9) of the studies involved natural science (science, physics, chemistry, biology), 23.3% (f = 7) involved math, 20% (f = 6) involved social science (social studies, history, geography), 16.7% (f = 8) involved English, 6.7% (f = 2) involved informatics and 3.3% (f = 1) involved music. In terms of study type; 53.3% (f = 16) of the studies are thesis and 46.7% (f = 14) are articles. In terms of learning style model; 43.3% (f = 13) of the studies employed the Perceptual Learning Styles Model, 33.3% (f = 10) employed the 4MAT Model, 6.7% (f = 2) employed the Kolb Learning Styles Model, 10.1% (f = 3) employed the Dunn & Dunn Learning Styles Model, 3.3% (f = 1) employed the Felder & Solomon and Brain

Dominance Model. In terms of experimental design, 86.7% (f = 26) of the studies used quasi-experimental design and 13.3% (f = 4) used true-experimental design. In terms of investigated variable, 58.0% (f = 29) of the studies investigated the effect of learning style on achievement, 22.0% (f = 11) investigated the effect of learning style on attitude and 20.0% (f = 10) investigated the effect of learning style on retention.

Findings Relating to the Effect of Learning Style Model on Achievement

Table 2 shows the meta-analysis results for the studies investigating the effect of courses tailored to students' preferred learning styles on academic achievement.

Table 2
Numbers, Standard Errors, Heterogeneity, 95% Confidence Intervals and Effect Size of the Studies according to Model Type

Model	N	Std. Error	Heterogeneity				Effect Size	95% Confidence Intervals	
			Q	df	p	I^2		Lower Limit	Upper Limit
Fixed Effect	29	0.045	112.96	28	0.000	75.21	1.039	0.951	1.128
Random Effect	29	0.095					1.029	0.843	1.216

According to Table 2, the result of the heterogeneity test was significant ($p < .05$). The Q-value was calculated as 112.96, with 24 degrees of freedom (df). This value exceeds the critical value of χ^2 with 24 df and confidence intervals of 95%. I^2 index is 75.21%, which means that there is a high amount of heterogeneity among the studies. These results reveal that the studies do not share a common effect size; namely, there is a significant difference among the effect size of the studies. In the circumstance, because true effect size will vary from study to study, it should be analyzed according to the random effect model, and the common effect is the estimate of the mean of these effects (Borenstein et al., 2009, pp. 76–77).

When the effect sizes of 29 studies included in this review were combined according to the random effect model, the common effect size was calculated as (d) 1.029 with 0.095 standard error, and 95% confidence intervals of 1.216 and 0.843. This common effect size is large according to the Cohen's (1988) classification. This d value is associated with a U_3 value of 84.1%. This means that the average student receiving instruction tailored to their learning styles (treatment group) scored higher on achievement tests than 84.1% of students receiving no instruction (control group).

Findings Related to Investigating Academic Achievement in Terms of Learning Style Model, Experimental Design and Course Type

In order to determine whether the common effect size of the learning styles on academic achievement shows a significant difference according to learning style model, type of study design and course type, categorical moderator analysis was performed.

In order to determine which model of learning styles is more effective for improving academic achievement, the effect sizes of the Perceptual Learning Styles Model, the 4MAT Model, the Kolb Learning Styles Model, and the Dunn & Dunn Learning Styles Model were compared. As the Felder & Solomon Learning Styles Model and the Brain dominance model were each only used in one study, they were not included in the meta-analysis.

The meta-analysis results for the effects of the learning styles model on academic achievement are summarized in Table 3.

Table 3
Heterogeneity, 95% Confidence Intervals and Effect Size of the Classifications according to Effect Models

Model Type		Heterogeneity			Effect size (Total)	95% Confidence Intervals	
		Q	df	*p*		Lower Limit	Upper Limit
Fixed	Within Groups	86.268	23	.000	1.084	0.986	1.182
	Between Groups	12.724	3	.005			
Random	Between Groups	4.030	3	.258	0.993	0.820	1.166

According to Table 3, the Q statistic, both within groups and between groups, yielded a significant ($p < .05$) result under the fixed effect model. This reveals that the classification made according to learning styles model does not share the same common effect size. In other words, the effect size calculated in terms of learning styles model is not homogeneous. In this case, it is not appropriate to use the fixed effect model; instead it is necessary to use the random effect model (Borenstein, 2011). In Table 3, the Q statistic calculated under the random effect model yielded no significant ($p > .05$) result. These results indicated that there is no meaningful difference among the effect sizes of the classifications made according to learning styles model.

Under the random effect model, the common effect sizes were as follows: studies employing the 4MAT System, 1.168 (0.860, 1.477); studies employing Perceptual Learning Style Model, 0.870 (0.653, 1.023); studies employing the Dunn & Dunn Learning Style Model, 1.331 (1.047, 1.087); studies employing the Kolb Learning Styles Model, 1.067 (−0.876, 3.009). The model with the largest effect on academic achievement is the Dunn & Dunn Learning Style Model and the model with the smallest effect on academic achievement is the Perceptual Learning Style Model.

The result of the moderator analysis performed to determine whether the effect of learning styles models on academic achievement showed a significant difference in terms of course type (natural science, social science, math, English, informatics) was summarized in Table 4.

Table 4
Heterogeneity, 95% Confidence Intervals and Effect Size of the Classifications according to Effect Models

Model Type		Heterogeneity			Effect Size (Total)	95% Confidence Intervals	
		Q	df	*p*		Lower Limit	Upper Limit
Fixed	Within Groups	95.780	23	.000			
	Between Groups	17.065	4	.002	1.040	0.952	1.129
Random	Between Groups	3.780	4	.437	1.014	0.820	1.207

According to Table 4, because the Q statistic under the fixed effect model yielded a significant result ($p < .05$), the heterogeneity hypothesis of the distribution of effect sizes was accepted according to the random effect model. Under the random effect model, the Q statistic yielded no significance result ($p > .05$). These results reveal that there is not a meaningful difference between the effects sizes of the classification created according to course type: namely the effect sizes of the courses tailored to learning styles model on the academic achievement are independent of course type.

Under the random effect model, the common effect sizes were as follows: studies conducted on the English course, 0.743 (0.332, 1.154); studies conducted on the natural science course, 1.165 (−0.836, 1.494); studies conducted on social science courses, 1.111 (0.664, 1.558); and studies conducted in informatics, 0.702 (0.060, 1.343). According to these results, the highest achievement was obtained in natural sciences (science, physics, chemistry, biology), the lowest achievement was obtained in informatics.

Table 5 shows the results of the moderator analysis performed to determine whether the effect of learning styles models on academic achievement showed a significant difference in terms of experimental design (quasi-experimental and true-experimental).

Table 5
Heterogeneity, 95% Confidence Intervals and Effect Size of the Classifications according to Effect Models

Model Type		Heterogeneity			Effect Size (Total)	95% Confidence Interval	
		Q	df	*p*		Lower Limit	Upper Limit
Fixed	Within Groups	106.51	27	.000			
	Between Groups	6.443	1	.011	1.039	0.951	1.128
Random	Between Groups	3.554	1	.059	1.010	0.823	1.197

According to Table 5, because the within-group heterogeneity under the fixed effect model yielded a significant result ($p < .05$), the heterogeneity hypothesis of the distribution of effect sizes was accepted according to the random effect model; but the heterogeneity test yielded no significant result ($p > .05$) under the random effect model. These results reveal that there is not a significant difference between the effects sizes of the classification created according to type of experimental design.

Under the random effect model, the common effect sizes were as follows: the studies with quasi-experimental design, 1.099 (0.890, 1.307); the studies with true-experimental design, 0.647 (0.226, 1.068); the design type, 1.010 (0.823, 1.197). According to these results, the common effect size of the studies with quasi-experimental design is larger than those with true-experimental design.

Findings Related to the Effect of Learning Style Models on Attitude and Retention

The result of meta-analyses of the studies investigating the effect on attitude of learning environments designed according to the learning styles models was summarized in Table 6.

Table 6
Heterogeneity, 95% Confidence Intervals and Effect Size of the Classifications according to Effect Models

Model Type	N	Standard Error	Heterogeneity				Effect Size	95% Confidence Intervals	
			Q	df	*p*	I2		Lower Limit	Upper Limit
Fixed Effect	11	0.085	66.385	10	.000	84.95	1.013	0.846	1.179
Random Effect	11	0.227					1.113	0.669	1.557

According to Table 6, the result of the heterogeneity test was significant ($p < .05$). The Q-value was calculated as 66.385, with 10 df. This value exceeds the critical value of χ^2 (18.307) with 10 df and confidence intervals of 95%. An I^2 index value of 84.95% shows that there is a high amount of heterogeneity among the studies. These results reveal that the studies do not share a common effect size, so the common effect size should be computed according to the random effect model.

When the effect sizes of 11 studies included in this review were combined according to the random effect model, the common effect size was calculated as (d) 1.113 with 0.227 standard error and 95% confidence intervals of 1.557 and 0.669. This common effect size is large according to the Cohen's (1988) classification. This d value is associated with a U_3 value of 84.1%, which means that the average student receiving instruction tailored to their learning styles scored higher on attitude tests than 84.1% of students receiving no instruction.

The result of meta-analyses of the studies investigating the effect of learning environments designed according to the learning styles models on retention was summarized in Table 7.

Table 7
Heterogeneity, 95% Confidence Intervals and Effect Size of the Classifications according to Effect Models

Model Type	N	Standard Error	Heterogeneity				Effect Size	95% Confidence Intervals	
			Q	df	*p*	I2		Lower Limit	Upper Limit
Fixed Effect	10	0.096	55.642	9	.000	83.83	1.173	0.985	1.360
Random Effect	10	0.241					1.763	0.817	1.763

According to Table 7, the heterogeneity test yielded a significant ($p < .05$) result. The Q-value was calculated as 55.642, with 9 df. This value exceeds the critical value of χ^2 (16.919) with 9 df and confidence intervals of 95%. With the value of 83.83%, I^2 index shows that there is a high amount of heterogeneity among the studies. These results reveal that the studies do not share a common effect size, so the common effect size should be computed according to the random effect model.

When the effect sizes of 10 studies included in this review were combined according to the random effect model, the common effect size was computed as (d) 1.763 with 0.241 standard error and 95% confidence intervals of 1.763 and 0.817. This common effect size is large according to the Cohen's (1988) classification. This d value is associated with a U_3 value of 90.3%. This means that the average student receiving instruction tailored to their learning styles scored higher on retention tests than 90.3% of students receiving no instruction.

Findings Relating to Publication Bias

In order to determine whether there is a publication bias, firstly the effect of learning styles models on academic achievement, attitude and retention was analyzed according to publication status (published and unpublished). That there is not a significant difference between the effect sizes of the published (articles) and unpublished (theses) studies is evidence of the non-existence of publication bias (Card, 2012, p.262). As a result of the moderator analysis, it was found that the effect of the learning style models on academic achievement ($Q = 0.016$, $p = .901$), attitude ($Q = 1.585$, $p = .208$) and retention ($Q = 0.000$, $p = .992$) did not show a significant difference ($p > .05$) according to the publication status under the random effect model.

In addition to moderator analysis, Egger's regression intercept test was performed to evaluate the potential impact of publication bias. If the intercept value (B_0) obtained as a result of Egger's regression intercept test significantly deviated from zero, it would indicate the possible existence of publication bias, and in contrast, if the intercept value (B_0) did not significantly deviate from zero, it would indicate the possible absence of publication bias (Card, 2012, p. 267). As a result of Egger's regression intercept test, the intercept value (B_0) was computed for achievement, attitude and retention as

−0.236 (p = .84), 2.440 (p = .41) and 7.756 (p = .09), respectively. According to these results, it was seen that the intercept value did not significantly ($p > .05$) deviate from zero for all three variables. Consequently, it can be said that the common effect sizes computed for all three variables did not result from publication bias.

Rosenthal's Fail-safe N test (Borenstein et al., 2009, p. 284) was performed to evaluate whether the observed effect size was robust or the common effect size resulted from publication bias. Rosenthal's Fail-safe N calculates how many missing studies with mean effect of zero need to be added to the analysis to render non-significant the p value of common effect size (Rosenthal, 1979). If the addition of a few studies (five to ten) nullify the common effect size, it can be concluded that the observed effect is not robust and can be resulted from publication bias (Borenstein et al., 2009, p. 274; Rosenthal, 1979). As a result of Rosenthal's Fail-safe N, it was computed that 3512, 409 and 416 studies with the mean effect of zero were needed to nullify the common effect size of the achievement, attitude and retention, respectively. According to these results, it can be said that the computed common effect sizes for achievement, attitude and retention are robust and do not result from publication bias.

Discussion and Conclusion

In this study, the results of 29 experimental studies, carried out in Turkey in 2004–2014, investigating the effect of learning styles on academic achievement were combined through meta-analytical review method. As a result of the heterogeneity test, it was found that the effect sizes of the individual studies were heterogeneous at high-level ($p < .05$, $I^2 = 75.21\%$). In this case, because true effect size will vary from study to study, it should be analyzed according to the random effect model. The common effect size was computed as 1.029 according to random effect model. This result indicates that the learning environment designed according to learning styles models has a large effect (d = 1.029) on academic achievement. It was identified that this d value was associated with a U_3 value of 84.1%. This value shows that the average student receiving instruction tailored to their learning styles can score higher on achievement tests than 84.1% of students receiving no instruction.

This finding is consistent with the result obtained from meta-analytical study conducted by Dunn et al. (1995) in order to investigate the effect of courses designed according to Dunn and Dunn Learning Styles on academic achievement. Dunn et al. (1995) found that the common effect was large (d = 0.755) as a result of the meta-analysis of 42 studies. Similarly, the result obtained from meta-analytical study conducted by Lovelace (2005) in order to investigate the effect of courses designed according to Dunn and Dunn Learning Styles Model on academic achievement and attitude supported this finding. Lovelace (2005) found that the common effect size for academic achievement was large (d = 0.755) as a result of the meta-analysis of 76 studies. The same results can also be seen in many individual studies, conducted both in Turkey and abroad. These studies reveal that students learn more effectively (e.g. increasing their academic achievement and having positive attitudes toward learning) in an instructional design that matches their learning styles (Aydıntan et al., 2012; Bozkurt & Aydoğdu, 2009; Constantinidou & Baker, 2002; Demir & Usta, 2011; Gökalp, 2013; Kaf Hasırcı, 2005; Mahiroğlu & Bayır, 2009; Özgen & Alkan, 2014; Yılmaz Soylu & Akkoyunlu, 2009).

There are also meta-analytical studies in literature that do not support the result obtained from this study. For example, Kavale and Fortness (1987) investigated the effect of learning environment designed according to Perceptual Learning Styles on academic achievement, and found that the common effect size was small (d = 0.14) as a result of the meta-analysis of 39 studies. This result indicates that the learning environment designed according to Perceptual Learning Styles has a small effect on academic achievement. Likewise, Slemmer (2002) examined the effect of learning styles in the technology enhanced learning environment on academic achievement, and computed the common effect size as 0.13 as a result of the meta-analysis of 48 experimental studies. Slemmer (2002) concluded that the learning styles had a small effect on academic achievement in the technology enhanced learning environment. Also, some individual studies found that the learning environment designed according to learning styles had no effect on achievement (Ariffin, Solemon, Din, & Anwar, 2014; Ateş & Çataloğlu, 2007; Çolak, 2013; Kim, 2013; Mahiroğlu & Bayır, 2009; Yılmaz Soylu & Akkoyunlu, 2002).

Another important conclusion emerging from this review is that the effect of the learning styles on academic achievement shows no meaningful difference according to learning style models. As a result of the categorical moderator analysis, the common effect sizes of the studies employing the 4MAT System, Perceptual Learning Style Model, Dunn & Dunn Learning Style Model and Kolb Learning Styles Model, were calculated as 1.168, 0.870, 1.331 and 1.067 respectively. According to these results, although having a large effect on academic achievement, learning styles models do not show a significant difference ($p > .05$) according to their effect on academic achievement. In other words, whether the courses are designed according to the Dunn & Dunn Learning Styles Model or 4MAT Model or other models, the academic achievement increases independently from the type of learning styles model. Likewise, Felder (1996) reached a similar conclusion in his article where he compared four significance learning styles models (Myers-Briggs Type Indicator, Hermann's Brain Dominance Model, Kolb Learning Styles Model and Felder-

Silverman Learning Styles Model). According to this, as these learning styles models have the same instructional approach, it is unimportant which model the educators choose, and in designing courses they can benefit from any of the models. Curry (1990) sees these models as the different parts of the same whole. According to him, the researcher of learning styles, as blind men trying to recognize the elephant by touching its different parts, try to examine only a part of the whole, and therefore they are not able to comprehend the issue before them. Hence, the claim that the academic achievement is independent of type of learning styles model is consistent with the result obtained from this study.

This study showed that learning environment designed according to learning styles does not show any significant difference ($p > .05$) in terms of course type (natural science, social science, mathematics, English, informatics). Accordingly, the learning environment designed according to learning styles enhanced academic achievement in natural science (physics, chemistry, biology and science) at most and in informatics at least. It was found that the common effect size computed for natural science, social science, mathematics and English were large (more than 0.80) and the common effect size for informatics was moderate (between 0.50 and 0.80). It was concluded that when the courses were tailored to students' learning styles, this instructional method increased students' achievement more than the traditional methods did.

Another result emerging from this study is that the learning environment designed according to learning styles does not show any significant difference ($p > .05$) in terms of type of experimental design (quasi or true). The common effect size of studies with quasi-experimental design and with true-experimental design was computed as 1.099 and 0.647, respectively. According to this result, while the common effect size of studies with quasi-experimental design on academic achievement is large, the common effect size of studies with true-experimental design is moderate, but it was found that this difference was not significant as a result of the moderator analysis. The main difference between these two designs is that while there is a random assignment in the true-experimental design, there is non-random assignment in quasi-experimental design (Büyüköztürk et al., 2008, pp. 142–156). Hence, the random and non-random assignment did not show any significant difference for students' academic achievement in this study.

However, Pashler et al. (2008) said that an experimental study designed to determine the effect of instruction based on learning styles has to meet these criteria in addition to true-experimental designs: (i) Students must be classified into groups in terms of their learning styles, and then students from each group must be randomly assigned to receive one of multiple instructional methods. (ii) All the students in groups must take the same exam. (iii) Students must receive instruction tailored to their supposedly preferred learning styles, in which there must be a specific type of interaction between learning style and instructional method, and namely the instructional method that proves most effective for students with one learning style is not the most effective method for students with a different learning style. If a specific type of interaction between learning style and instructional method was not formed, whether the increase in the student academic achievement resulted from learning styles or not would not be determined. According to Glenn (2009), in such a case, one possible reason for the increase in achievement is that regarding variety of learning styles, teachers begin to pay more attention to their instruction and enrich their instruction by using a variety of methods.

In these meta-analytic review, it was found that when student received an instruction tailored to their learning style, their attitude (d = 1.113) toward courses improved and their learning was more permanent (d=1.290). According to these results, it can be said that the learning environment designed based on learning styles has a large effect on students' attitude toward course and learning retention. The percentage value of U_3 from the table of d index-U_3 effect size metrics (Cohen, 1988, p. 22) was specified for attitude and retention as 84.1% and 90.3%, respectively. These percentage values indicate that the average student receiving instruction tailored to their learning styles scored higher on attitude and retention test than 84.1% and 90.3% of students receiving no instruction, respectively.

The result obtained for the attitude is in parallel with results obtained from meta-analytical study conducted by Lovelace (2005) in order to investigate the effect of courses designed according to the Dunn and Dunn Learning Styles Model on academic achievement and attitude. Lovelace (2005) computed common effect size for attitude as 0.85 as a result of the meta-analysis of 76 studies. This value is large according to Cohen's (1988) classification. The individual studies in national literature also support the finding that the learning styles have an effect on attitude toward course (Bozkurt & Aydoğdu, 2009; Elçi, 2008; Evin Gencel, 2008; Güven, 2007; Yılmaz & Dinçol Özgür, 2012) and retention (Cengizhan, 2007; Güven, 2007; Yılmaz & Dinçol Özgür, 2012; Yazıcılar & Güven, 2009).

Suggestions

As a result of this meta-analytical review conducted to investigate the effect of courses designed according to learning styles on academic achievement, attitude and retention, the following suggestions were made for teacher and researchers. (i) When designing learning experiences according to any of the learning style model (independent of the type of learning style model), the teachers can enhance their students' academic achievement, attitude toward course and retention level. (ii) It was found that the studies included in this review mostly employed the 4MAT Model and the Perceptual Learning Style Model. The effectiveness of other learning styles models can also be investigated in studies to be conducted in the future. (iii) It was found that the studies relating to learning styles were mostly conducted in the courses of natural science, social science, math and English. The studies to be carried out in the future can be conducted in other courses. (iv) The effect of learning styles on academic achievement, attitude and retention was mostly investigated in the studies included in this review. The effect of learning styles on motivation, self-efficacy and skills (creative and critical thinking, problem solving and scientific process skills) can be investigated. (v) In order to provide experimental evidence to the existence of learning styles, the studies should be designed according to the criteria determined by Pashler et al. (2008). In other words, groups should be created according to learning styles by using true-experimental designs, and they should be given instruction appropriate to learning style (so that an instructional method effective for one learning style must not be effective for another learning style).

Limitations

This meta-analytical review was limited to the studies conducted in Turkey in 2004–2014, and with the studies to be accessed in the electronic media. Hence, the studies conducted abroad and published out of the electronic media were not included in this review. Similarly, there are also many individual studies designed to a relational research model in the literature. A future meta-analytical study, which will take these limitations into consideration, is thought to contribute to the literature.

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(The studies with asterisk indicate that the studies are included in this review.)

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